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GEOLOGICAL SURVEY OF ALABAMA
EUGENE ALLEN SMITH, *State Geologist*

BULLETIN NO. 19

STATISTICS OF THE MINERAL PRODUCTION OF ALABAMA FOR 1915

COMPILED FROM THE MINERAL RESOURCES OF THE UNITED STATES

By
EUGENE A. SMITH

UNIVERSITY, ALABAMA
1917

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LETTER OF TRANSMITTAL

UNIVERSITY, ALA., March 20, 1917.

HON. CHARLES HENDERSON,
Governor of Alabama,
Montgomery, Ala.

SIR:—I have the honor to transmit herewith the manuscript of a Report on the Mineral Production of Alabama for the year 1915 with the request that it be printed as Bulletin No. 19 of the Geological Survey of Alabama.

Very respectfully,
EUGENE A. SMITH,
State Geologist.

GEOLOGICAL CORPS.

Eugene Allen Smith, Ph. D.	State Geologist
William F. Prouty, Ph. D.	Chief Assistant
Robert S. Hodges	Chemist
Herbert H. Smith	Curator of Museum
Roland M. Harper, Ph. D.	Botanist
A. T. Donoho	Stenographer
Geo. N. Brewer	Field Assistant

RIVER GAGE HEIGHT OBSERVERS.

A. L. Stowe	Jackson's Gap, Tallapoosa River
J. E. Whitehead	Riverside, Coosa River
A. W. Lambert	Beck, Conecuh River
Ed. Bullen	Red Bay, Big Bear Creek

From the records of daily observations of the gage readings at these places when extended through sufficient time, the calculation of available horsepower to be obtained from the different streams is made.

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PREFACE

The statistics of all the minerals included in the following pages have been collected in coöperation with the United States Geological Survey, and have been compiled from advance chapters of the *Mineral Resources of the United States*, a publication of the Federal Survey.

The introductory and general matter in each of these articles has either been taken without change from the U. S. advance chapters or has been rearranged or condensed from these chapters, or entirely rewritten to suit it to our present purposes. In each case credit is given to the author.

INTRODUCTION

EUGENE A. SMITH.

AN INSPECTION of the subjoined table will show that there has been in 1915 an increase both in quantity and value of cement, clay, graphite, iron ore, pig iron and lime, with a slight decrease in the value of clay products; a decrease both in quantity and value of coal, gold, silver and mineral waters; an increase in quantity but decrease in value, of sand and gravel and stone, and a slight decrease in quantity but increase in value of coke.

Following the plan set out by Mr. E. W. Parker in 1913, and continued by the Alabama survey, we pass in review the production in 1914 and 1915 of Alabama minerals, and their immediate derived products, taking them up somewhat in the order of their commercial importance.

Coal.—Alabama's production of coal in 1915 was 14,927,937 short tons, valued at $19,066,043, a decrease of 4.3 per cent in quantity, and 8.6 per cent in value as compared with 1914. As in 1914, the value of the coal product of Alabama in 1915 was approximately two-thirds of the total mineral output of the State.

Coke.—The coke production of Alabama decreased from 3,084,149 short tons, valued at $8,408,443 in 1914, to 3,071,811 tons, valued at $8,545,555 in 1915, an increase in the value of $137,112, or 1.6 per cent.

Iron Ore.—There was in 1915 an increase of 13.7 per cent in the total quantity of iron ore production, 16.9 per cent in the quantity of the hematite, and 1.1 per cent in the quantity of brown ore.

In the quantity of pig iron marketed in Alabama in 1915, there was an increase from 1914 of 39.6 per cent, and an increase of 35.9 per cent in the value.

The value of this iron ore production, and not the value of the pig iron, is used in making up the total value of the mineral products of the State.

The total value of the mineral production of Alabama, excluding the value of the pig iron and coke and including the value of the iron ores and the coal, was $29,457,407 in 1915, compared with $30,879,288 in 1914, of which as already stated, approximately two-thirds is represented by the products of the coal mines. Nearly one-fourth of the total value was contributed by the iron mines. The decrease in 1915 from 1914 was $1,421,881, or 4.6 per cent.

The principal coal producing counties are Jefferson, Walker, Bibb, Tuscaloosa, and St. Clair, in the order named. The principal iron ore counties are Jefferson, Tuscaloosa, Franklin, and Etowah. The combined value of the pig iron and coke made in Alabama in 1915, was $32,302,679. These values are not included in the total as they are represented in the value of the iron ore and coal produced.

Clay-Working Industries.—These industries yielded products in 1915 valued at $1,193,022, against $1,574,023 in 1914, a decrease of $381,001 or 24.2 per cent. This does not include the value of the raw clay sold, which in 1915 amounted to $35,232, an increase from 1914, or 1.8 per cent.

The center of the clay-working industry is Jefferson county, and Birmingham furnishes the principal market. Vitrified, front, and fire brick, represent a value of $578,134, or 151.3 per cent of the value of the common brick, while the total output of the brick yards makes up over 80 per cent of the State's total clay products. All the fire brick is reported from Jefferson and Calhoun counties and all the vitrified brick is from Jefferson county. Clay pits for the manufacture of common brick have been opened in one or more places in thirty different counties.

Stone.—The quarry products, the larger part of which is limestone, were valued in 1915 at $719,452, a decrease of 45.4 per cent, from $1,319,753 in 1914.

The decreased production in 1915 was in the output of limestone, for rough building stone, road making, flux, concrete, and for agricultural purposes: for sandstone used for rough building purposes; and the production of marble.

Over 59 per cent of the total value of the stone production is limestone. Its most important uses are for furnace flux, concrete, road making, for building purposes and for agricultural uses. Until 1914 comparatively little of Alabama limestone was used for building purposes, but there has been in 1915 a decrease of 46 per cent along this line. In the production of marble there has also been a notable decrease in 1915. The reader is referred to the body of this Bulletin, under Stone, for further details concerning especially, the building stones and marble industries.

Marble holds the second place in the value of quarry products, a beautiful white marble, occurring in Coosa and Talladega counties, being extensively used for building (both inside and outside work), and a black marble which gives promise of future development, has been prospected near Anniston and near Piedmont.

Cement.—The cement production of Alabama amounted in 1915 to 1,114,386 barrels, valued at $891,483, as against 777,698 barrels in 1914, valued at $746,555, an increase of 43.3 per cent in quantity, and of 19.4 per cent in value.

Lime.—The lime production is not included in that of the limestone, and amounted to 60,332 short tons, an increase from the 1914 production, of 13,366 short tons, or 24.8 per cent. The value of the product was $250,227, an increase of $50,413, or 25.2 per cent.

Graphite.—The Alabama graphite is all of the crystalline variety, and the value of the product in 1915 was $204,572, as against $118,000 in 1914, an increase of 44.2 per cent. The Alabama production for 1915 was 49 per cent of the total value of the crystalline graphite produced in the United States, and 47.6 per cent of the total value of amorphous and crystalline combined. The great increase in production in 1915, and the installing of a number of new plants, not in active operation in 1915, make it probable that the Alabama production in 1916 and following years, will represent an even larger proportion of the U. S. total value.

Minor Products.—Alabama produces a small quantity of gold and silver, and other minor products are bauxite, mica, millstones, mineral paints, (natural pigments), mineral waters, natural gas, sand and gravel, and quartz.

In the following table is represented a comparison of the mineral output of Alabama in 1914 and 1915. As stated above, the total does not include the value of pig iron or that of coke, but it does include the value of the coal made into coke, and of the iron ore sold or used.

Mineral production of Alabama in 1914 and 1915.

Product.	1914				1915			
	Raw.		Derived.		Raw.		Derived.	
	Quantity.	Value.	Quant'y.	Value.	Quantity	Value.	Quantity.	Value.
Barytes, short tons	(*)	(*)			(*)	(*)		
Bauxite, long tons	(*)	(*)			(*)	(*)		
Cement, barrels			777,698	$746,555			1,114,386	$891,488
Clay products, short tons	27,973	†$34,607		1,574,028	31,870	†$35,232		1,193,022
Coal, short tons	15,593,422	20,849,919			14,927,987	19,066,043		
Coke, short tons			3,084,149	†8,408,448			3,071,811	†8,545,555
Ferro-alloys, long tons			(*) (†)	(*) (†)			(*) (†)	(*) (†)
Gold, fine ounces (troy)			579	11,970			254	5,248
Graphite, crystalline, pounds	2,410,200	118,009			3,474,800	204,572		
Iron ore, long tons	4,514,926	5,727,619			5,184,955	6,798,266		
Iron, pig, long tons			1,661,420	†17,481,828			2,320,255	†28,757,124
Lime, short tons			46,966	199,814			60,332	250,227
Manganese ore, long tons					200	(*)		
Mica				(*)				5,940
Millstones				(*)				
Mineral paints, natural pigments, short tons			(*)	(*)			(*)	(*)
Mineral waters, gallons sold	169,279	17,125			86,499	8,912		
Natural gas		(*)				(*)		
Sand and gravel, short tons	831,430	262,219			924,701	242,336		
Silver, fine ounces (troy)			199	110			12	6
Stone		(‡)		‡1,319,758		(‡)		‡719.452
Miscellaneous		42,382		336,325		68,561		571,592
Total value, eliminating duplications	$30,879,288				$29,457,407			

*Value included under "Miscellaneous." †Value not included in total value. ‡Stone sold rough included in derived products.

STATISTICS OF THE MINERAL PRODUCTION OF ALABAMA FOR 1915

ABRASIVES.

EUGENE A. SMITH.

ALABAMA'S production of abrasives is at present limited to a small number of millstones (chasers*) quarried and made at Dutton, Jackson County; there are, however, several materials in different parts of the State which are sufficiently promising to be worth investigating and thorough testing; the nature and locality of these deposits were treated in Bulletin No. 13, which see.

BARYTES.

(Condensed from Mineral Resources of the United States.)

JAMES M. HILL.

ALABAMA again entered the list of producers of barytes in 1915. One deposit in Calhoun County was worked and it is authoritatively reported that a deposit near Leeds, Jefferson County, will be exploited during 1916. The 1915 output was sold to manufacturers of lithopone. On account of small number of producers the exact figures of 1915 production cannot be given.

---

*Chasers are larger than the regular millstones. They are used for heavier work, such as grinding quartz, feldspar, barytes, etc., and they run on edge. Though they are made with a diameter as short as 24 inches, they are usually turned out with diameters ranging from 50 to 84 inches, and are as much as 22 inches in thickness. These chasers are run on pans paved with roughly cubical blocks of the conglomerate, with edges about a foot in length. In grinding quartz in such pans the chasers are used in the preliminary crushing; then rough blocks, usually three in number, are either, attached to or carried along by lateral arms, which in turn are joined to a vertical revolving shaft. By the circular movement of these blocks the material placed in the pan is ground to powder.

The commercial barytes deposits of Alabama[1] are of the residual type; most of the better-known deposits are located in the central and northeastern part of the State, including Bibb, Calhoun, Etowah, Jefferson, Shelby, and St. Clair counties. Lower Paleozoic rocks underlie parts of all these counties and the Knox dolomite (of Cambrian and Ordovician age) and the Chickamauga limestone (of Ordovician age) outcrop in them. These formations, from which the barite is derived, outcrop in narrow northeastward-trending bands, whose position is determined by the folding and faulting that formed the Appalachian Mountains. The more important deposits are near the contact of the two formations, though some deposits are found in residual clays derived entirely from the Knox dolomite. Barite-bearing veins are found in the dolomite and limestone. Alabama barite is of good quality, usually pure and white, but sometimes colored and iron-stained. The barite from some localities is associated with galena. The principal cause of the lack of development of the deposits in the past appears to have been the distance to grinding mills and other consumers.

The barytes deposits of Alabama which have thus far been developed are in clays derived from the weathering of limestones and dolomites of Cambrian and Ordovician age. The barytes in the residual deposits was originally in veins or replacements in the limestone rocks. Owing to the slight solubility of the barytes and the silica (quartz and chert), these minerals resisted the agencies of weathering and were left behind with the clay upon the removal of the soluble constituents of the original formation.

The distribution of the barytes in the original rocks seems to have been influenced largely by the presence of openings through which solutions carrying barium could penetrate.

Thus, in Alabama and some other states the barytes deposits are located along or near zones of folding and faulting of the late Cambrian and Ordovician rocks.

---

[1] Butts, Charles, U. S. Geol. Survey Geol. Atlas, Birmingham folio (No. 175), 1910.

Grasty, J. S., Mineral resources of the South; Barite deposits of Alabama; The Tradesman, July 18, 1918, pp. 85-86.

Hayes, C. W., U. S. Geol. Survey Geol. Atlas, Gadsden folio (No. 35), 1896.

Smith, E. A., Report of progress for 1875, p. 95, Alabama Geol. Survey, 1876.

Smith, E. A., and McCalley, Henry, Index of the mineral resources of Alabama, pp. 62-63, Alabama Geol. Survey, 1904.

Watson, T. L., and Grasty, J. S., Barite of the Appalachian States: Am. Inst. Min. Eng. Bull. 98, pp. 351-353, February, 1915.

BARIUM PRODUCTS.

For many years ground and floated barytes has been produced at various plants located in Kentucky, Missouri, North Carolina, South Carolina, Tennessee, and Virginia. Prior to 1914 a small quantity of barium chemicals was made in the United States, though there is little published information relative to this industry. It would appear that practically all the barium chemicals heretofore used were imported either from Germany, England, or France. In each of those countries there were barium chemical plants, though the industry was apparently most highly developed in Germany and England.

THE MANUFACTURE OF GROUND BARYTES.[1]

The treatment of crude barytes to make ground barytes varies in different plants. The general practice. however, seems to be to crush to about 1 inch and log-wash and jig to remove clay, calcite, flourite, silica, and part of the iron oxide. This cleaned material is next crushed to one-fourth to one-eighth inch at some plants, and at others ground fine and subjected to a bleaching process. The bleaching, largely to remove iron oxide, is accomplished by treating the material with sulphuric acid from 8 to 12 hours in lead-lined wooden tanks. The bleached product is washed several times and ground in burr mills or pulverizers to pass 200 to 300 mesh, and in some plants is water floated to insure a uniformly fine product, and is then dried, pulverized, and packed. Much care is required not only in the bleaching, but also in the drying operation to insure a uniformly perfect color. Details of the manipulation during bleaching and of the drying machinery are not made public.

The softer grades of barytes are preferred by the grinders, as there is less wear on the machines in treating this class of material. However, in some plants, hard crystalline barytes is ground successfully. Several grades of ground barytes are on the market, varying from unbleached, coarsely-ground material to the finest grade of white-bleached and water-floated pigment. The following list includes all the companies reporting a production of ground barytes:

---

[1] The sections of this report dealing with the manufacture of barium products have been read and criticised by Mr. Hugh Rollin, of the Rollin Chemical Co., and Mr. Maximilian Toch, of the Durex Chemical Co., to whom the Survey desires to express its appreciation for their courtesy.

Barbour Chemical Works, 707 West Coast Life Building, San Francisco.
Carolina Chemical Co., Stackhouse, N. C.
Cherokee Chemical Co., 109 Hollingsworth Street, Baltimore, Md.
Elkhorn Chemical Co., Elsinore and Gilbert Avenues, Cincinnati, Ohio.
J. C. Fink Mineral & Manufacturing Co., 101 Barton Street, St. Louis, Mo.
Nulsen, Klein & Krausse Manufacturing Co., Levee and Sidney Streets, St. Louis, Mo.
Point Milling & Manufacturing Co., Mineral Point, Mo.
Product Sales Co., 423-425 Equitable Building, Baltimore, Md.
Thompson, Weinman & Co., 100 William Street, New York, N. Y.

The Manufacture of Lithopone.

Lithopone is a mixture of approximately 70 per cent barium sulphate, 25 to 29 per cent zinc sulphide, and 1 to 5 per cent zinc oxide, which is made by mixing hot solutions of barium sulphide and zinc sulphate. In the preparation of high-grade lithopone the solutions of barium and zinc compounds must be essentially pure. The precipitate from the tanks is filter-pressed, dried, subjected to considerable heat, quenched in water, ground to pulp, filter-pressed, dried, and packed for shipment. A recent paper by O'Brien* brings out the important points in the preparation of lithopone and indicates some of the features necessary to produce a light-proof product. Lithopone is sold under a great variety of trade names, such as Beckton White, Green Seal, Blue Seal, Sterling White, Fulton White, Phonolith. The following list includes the manufacturers who reported production in 1915 or prospective production in 1916:

Beckton Chemical Co., 3500 Grays Ferry Road, Philadelphia, Pa.
Grasselli Chemical Co., Cleveland, Ohio.
N. Z. Graves Corporation, 22-24 South Third Street, Philadelphia, Pa.
Krebs Pigment & Chemical Co., Newport, Del.
Mantua Chemical Co., 3500 Grays Ferry Road, Philadelphia, Pa.
Midland Chemical Co., 80 East Jackson Boulevard, Chicago, Ill.
New Jersey Zinc Co., 55 Wall Street, New York, N. Y.

***O'Brien, W. S., A Study of Lithopone: Journal of Phys. Chem., Vol. 19, pp. 113-144, 1915.**

THE MANUFACTURE OF BARIUM CHEMICALS.

The principal barium chemicals made in the United States are the binoxide, carbonate, chloride, hydroxide, nitrate, and sulphate or blanc-fixe. Some crude barium sulphide ("Black Ash") is sold to makers of lithopone and manufacturers of chemicals who are not equipped to roast sufficient barytes to meet their needs.

The following companies reported to the U. S. Survey that they had made barium chemicals during 1915 or were about to begin the manufacture of one or more of the chemicals early in 1916:

Barbour Chemical Works, 707 West Coast Life Building, San Francisco, Cal.
Baryta Manufacturing Co., 205 Pearl Street, New York, N. Y.
Chemical Products Co., 616 Majestic Building, Denver, Colo.
Chicago Copper & Chemical Co., 111 West Jackson Boulevard, Chicago, Ill.
Clinchfield Products Co., 120 Broadway, New York, N. Y.
Durex Chemical Co., 320 Fifth Avenue, New York, N. Y.
Elkhorn Chemical Co., Elsinore and Gilbert Avenues, Cincinnati, Ohio.
Globe Chemical Co., 1205 Regent Avenue, Cincinnati, Ohio.
Lamar Chemical Works, 44-56 Lewis Avenue, Jersey City, N. J.
Port Morris Chemical Works, 141 Locust Avenue, New York, N. Y.
Rollin Chemical Co., Charleston, W. Va.

USES OF BARIUM CHEMICALS.

Ground barytes of the lower unbleached grades is sold to manufacturing chemists and to paint manufacturers for incorporation in colored mixed paints; it can also be used in the preparation of rubber and in other industries where a colored product is made. The bleached and floated barytes of the finer grades is used as a white pigment in the preparation of ready mixed white paints and as a filler for the chemical pigments. In the paper industry it is largely used in the manufacture of heavy, stiff materials such as playing cards, bristol boards, and the like.

Lithopone is sold and used as a white pigment for ready mixed paints, being particularly used for the preparation of what are called the "sanitary flat wall paints," which are used to a large extent. It is also used in some enamels and calsomines, and in the rubber, paper, and cloth industries, where it is replacing barytes and some of the metallic pigments.

The barium chemicals have a wide variety of uses and may enter into the manufacture of other products. In the study of the industry the products have not been followed beyond the plants at which the chemicals are made from crude barytes. Barium binoxide or peroxide (BaO_2) apparently finds its principal market with the manufacturers of hydrogen peroxide, though some is believed to be used in the preparation of oxygen. This salt has the property of giving up part of its oxygen under certain conditions and of recombining with more oxygen under reverse conditions. This property is not, however, everlasting, and fresh supplies of the peroxide are frequently required.

Barium carbonate is used in the preparation of other barium chemicals—in rat poisons, as a water softener, in the manufacture of flat wall paints, and in the ceramic industry. Probably the last is its largest use at present. It is said that this material will fill the requirements of case-carbonizing steel, which was formerly filled by ground bone. Ground bone, which formerly commanded a price of $60 a ton, has risen in price and the makers of case-carbonized steel have been in search of a substitute. The barium carbonate for this purpose must contain no sulphur, but may carry calcium and small amounts of other impurities. It is said that the demand should be several thousand tons a year.

Barium chloride is used in the preparation of other barium salts, as a water softener, a chemical reagent, particularly for the purification of table salt, to some extent in the ceramic arts, and in the preparation of rat poisons.

Barium hydroxide is used as a chemical reagent. It can be used in the refining of sugar, but on account of its poisonous nature is not often employed; another reason why it is not used is the difficulty of its regeneration from the carbonate which is formed by the reactions.

Barium monoxide has its principal use in the preparation of the binoxide and hydroxide. It is used to some extent in the manufacture of special glasses.

Barium nitrate is used as a chemical reagent in the preparation of "green fire" and green signal lights and in the manufacture of an explosive known as saxifragin.

Barium sulphate, usually sold under the name of blanc-fixe or permanent white, is a pigment extensively used in the paint industry, in the manufacture of highly glazed papers and of putty, and in the fabrication of rubber and of lake colors.

BAUXITE.

THE production of bauxite in Alabama for 1915 was limited to one producer, which accounts for the joining of the Alabama and Georgia totals.

The following table gives the production and value of bauxite from 1899 to 1915 inclusive:

Production of bauxite in the United States, 1889-1915, by States, in long tons.

Year.	Georgia.	Alabama.	Arkansas.	Total.	Value.
1889	728	....	....	728	$2,366
1890	1,844	....	....	1,844	6,012
1891	3,301	292	....	3,593	11,675
1892	5,110	5,408	....	10,518	34,188
1893	2,415	6,764	....	9,179	29,507
1894	2,050	9,016	....	11,066	35,818
1895	3,756	13,313	....	17,069	44,000
1896	7,313	11,051	....	18,364	47,338
1897	7,507	13,083	....	20,590	57,652
1898	....	....	....	25,149	75,437
1899	15,736	14,499	5,045	35,280	125,598
1900	19,739		3,445	23,184	89,676
1901	18,038		867	18,905	79,914
1902	22,677		4,645	27,322	120,366
1903	22,374		25,713	48,087	171,306
1904	21,913		25,748	47,661	235,704
1905	15,173		32,956	48,129	240,292
1906	25,065		50,267	75,332	368,311
1907	....		....	*97,776	480,330
1908	14,464		*37,703	52,167	263,968
1909	22,227		*106,874	129,101	679,447
1910	33,096		*115,886	148,982	716,258
1911	30,170		*125,448	155,618	750,649
1912	19,587	14,173	*126,105	159,865	768,932
1913	27,409		*182,832	210,241	997,698
1914	18,547		*200,771	219,318	1,069,194
1915	25,008		*272,033	297,041	1,514,834

*Production of Tennessee included.

The Republic Mining & Manufacturing Co. was the only one that operated in Alabama in 1914. The company worked near Rock Run, Cherokee County, in the eastern part of the State.

USES OF BAUXITE.

W. C. PHALEN.

The chief uses of bauxite are as follows: (1) As raw material in the production of metallic aluminum; (2) in the manufacture of aluminum salts; (3) in the manufacture of bauxite bricks; (4) in the manufacture of alundum (fused alumina) for use as an abrasive. The use of bauxite in the manufacture of calcium aluminate to give a quick set to plaster compositions should be added, as well as the extended use which alundum is finding in the refractory industries.

1. The use of bauxite in the production of metallic aluminum is by far the most important of those enumerated. A large part of the output of Arkansas is so used, and the figures of production from this State have shown remarkable growth during recent years. A large part of the imported French bauxite has also been used in the manufacture of metallic aluminum.

2. Only the purer bauxite is used in the manufacture of chemicals, such as alum, aluminum sulphate, and aluminum salts in general. For this use freedom from oxide of iron is essential.

3. Bauxite is used in the manufacture of bauxite bricks for furnace linings. The purer the bauxite used, the more refractory is the resulting brick; moreover, the addition of bauxite to refractory clays not only increases their content of alumina but also their refractoriness. The method of making bauxite brick, a representative analysis of them, and the troubles sometimes encountered in their use where set forth in Mineral Resources for 1913.

Kenneth Seaver[1] has discussed the use of alumina in making bauxite brick. The two kinds of brick in common use, made of hydrous oxide of aluminum, contain 56 and 77 per cent alumina, percentages which represent the extreme proportions of alumina of value in this industry. The characteristics of these two kinds of brick are quite different. The brick containing 56 per cent alumina is used as a fire-clay brick, but it will withstand higher heat. The brick containing 77 per cent alumina has been used as a substitute for magnesia brick, commonly called magnesite brick, for open-hearth and similar work. It has given excellent results. Under normal conditions it probably can not be produced as cheaply as magnesite brick.

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[1] Am. Inst. Min. Eng., December, 1915, pp. 2505-2506.

An instance is cited where bauxite brick were used in the port end of the furnace, forming a bulkhead for that particular open-hearth furnace for 365 heats, at the end of which time a new roof was installed. The opposite port, in which mangesia brick were used, was found in worse condition. There seem to be great possibilities connected with the use of alumina brick.

4. Bauxite is used on a large scale at Niagara Falls in the manufacture of the artificial abrasive alundum. This abrasive is made in the electric furnace by fusing calcined bauxite. It is high in crystalline aluminum oxide and virtually amounts to a form of artificial corundum. The quality of the product is under complete control and can be duplicated with ease for use in the various abrasive processes, a factor of great importance in any successful abrasive industry. Alundum is particularly efficient in the grinding of steel.

5. The application of bauxite in the manufacture of calcium aluminate to give a quick set to plasters is discussed in Mineral Resources for 1911.[2]

ALUMINUM.

W. C. PHALEN.

PRODUCTION AND CONSUMPTION.

THE United States leads the nations in the production of metallic aluminum, and the marked increase in production in the United States is well illustrated by the figures given in the accompanying table. These figures give production to 1903 and consumption of the metal since that year.

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[2] Phalen, W. C., Bauxite and aluminum; U. S. Geol. Survey Mineral Resources, 1911, pt. 1, p. 981, 1912.

Aluminum produced or consumed in the United States, 1885-1915, in pounds.

1885	283	1896	1,300,000	1907	*17,211,000
1886	3,000	1897	4,000,000	1908	*11,152,000
1887	18,000	1898	5,200,000	1909	*34,210,000
1888	19,000	1899	6,500,000	1910	*47,734,000
1889	47,468	1900	7,150,000	1911	*46,125,000
1890	61,281	1901	7,150,000	1912	*65,607,000
1891	150,000	1902	7,300,000	1913	*72,379,000
1892	259,885	1903	7,500,000	1914	*79,129,000
1893	333,629	1904	*8,600,000	1915	*99,806,000
1894	550,000	1905	*11,347,000		
1895	920,000	1906	*14,910,000		556,672,546

*Consumption. The figures for 1915 do not include the weights of imported leaf aluminum, valued at $1,294; table, kitchen, and hospital utensils, and other similar hollow ware, valued at $32,435; wire, valued at $39,021; and "All other manufactures" of aluminum, valued at $42,083.

The secondary aluminum produced in 1915 was 5,700 short tons; the recovered aluminum contained in alloys was 2,800 short tons.

USES OF ALUMINUM.

The rapid increase in consumption of metallic aluminum shows that the metal is gaining in favor on account of several of its inherent qualities, among which are lightness, comparative toughness, durability, and resistance to chemical corrosion. The fact that aluminum has been successfully soldered and welded enables it to take its place among the most useful of the metals. The outlook for metallic aluminum in the future is exceedingly bright.

Improvement in foundry methods for casting metallic aluminum, the result of long experience and of increased knowledge of suitable alloys, has made it possible for metallic aluminum to compete both with other sheet metals and with wood in the manufacture of automobile bodies. Large sections of aluminum castings are now in use in making touring cars and the inclosed bodies of certain other motor cars, which was not practicable 10 years ago. Cast aluminum is now also used for making automobile dashes. The advantages of aluminum construction are that bodies made of it are lighter than those made of other sheet metal and have a rigid surface which will not dent easily when handled. They are also safer in case of accident. The aluminum surface retains paint well, and the increased rigidity makes the car more durable.

The applications of metallic aluminum during the war in Europe have been many, and consequently the demand for it has been great. Duralumin, an alloy of aluminum containing 3 per cent of copper and 1 per cent of magnesium, has been extensively used in the manufacture of cartridges for rifles, shells, helmets, grenades, and, with soft iron, of shell fuses. In France its use in cartridges is said to have been abandoned, but there has been a great demand for it everywhere for camp equipment and in the construction of air craft of all kinds. In the United States its use in the manufacture of automobiles, air ships, and miscellaneous war supplies has been very great.

During the last few years steel-reinforced aluminum cables have come into use for overhead power lines. In the cable the aluminum wires are laid over a core of high-tensile steel, which bears the greater part of the strain when the cable is erected. The price of aluminum having become so high, it is reported that certain transmission lines in the United States have actually been replaced by copper wire with substantial financial gain. Reported thefts of aluminum wire attest the present value of the metal.

The uses of aluminum dust or powder have been mentioned in preceding reports. The powder is of value in metallurgy as a precipitant of the precious metals in the cyanide process. It is also used as a reducing agent, as in the Goldschmidt thermit process of welding. It is a constituent of bronze powder in the preparation of aluminum paint. One of the most interesting uses of aluminum dust at the present time is in the manufacture of explosives. Aluminum dust mixed with ammonium nitrate produces an explosive called "ammonal" that has given good results in mining and in shells. It has the advantage of being insensitive, is very stable, and is found to remain in good order for long periods.

Process of Producing Metallic Aluminum.

Greenville Mellen has patented a process for extracting aluminum from clay, kaolin, or aluminum silicates in general, which is as follows: The clay is fused with sodium sulphate in the presence of sulphuric acid, or with its equivalent of acid sodium sulphate, in such proportion as to form aluminum sulphate and free silica. The fusion product after cooling is dissolved in water, filtered, and treated with sodium fluoride. The aluminum fluoride which separates is fused with common salt and is electrolyzed.

Interesting and instructive accounts of aluminum alloys, aluminum solder, and the production of aluminum salts may be seen in Part I of the Mineral Resources of the United States for 1915, by W. C. Phalen of the U. S. Geological Survey.

CEMENT.

EUGENE A. SMITH.
E. F. BURCHARD.

DURING the past seven years only one establishment in Alabama has been engaged in the manufacture of slag cement, using the material from the furnaces about Birmingham. The production is included in the returns for Portland cement and cannot be given separately.

PORTLAND CEMENT.

RESOURCES.

Alabama contains large supplies of limestone, chalk, clay and shale well adapted to Portland Cement manufacture, and widely distributed throughout the State. Coal and labor are abundant and cheap, transportation facilities are excellent, and many of the best limestone and chalk localities are situated on navigable rivers, giving ready access and cheap water transportation to Galveston, New Orleans, Mobile, Charleston, and other ports of the Gulf and Atlantic Coasts. This advantage of location was immensely increased with the opening of the Panama Canal for cement plants located in Alabama are more than a thousand miles nearer to the Isthmus than their nearest possible competitors.

The limestones and shales of the northern part of the State lie so close to each other, and above all so close to the great coal mines which must supply the fuel, that the establishment of Portland Cement plants near the coal mines would give to this industry in Alabama the same advantages which the proximity of the iron ore, the coal, and the stone has given to the iron industry, and which has placed our State beyond competition.

As a Portland cement mixture, ready for burning, consists approximately of 75 per cent lime carbonate and 25 per cent of clayey matter, the material furnishing the lime carbonate is necessarily of more economic importance than that from which the silica and alumina are derived. In consequence, a Portland cement plant is usually located in the immediate vicinity of a suitable limestone, while the clay or shale required to complete the mixture may be brought some distance.

The limestone formations in North Alabama which can supply the stone adapted for use in cement manufacture are the Trenton or Pelham limestone and the Bangor or Subcarboniferous. In close proximity to both these limestone formations are the shales of the Clinton, Subcarboniferous and Coal Measures.

At the present time there are two cement plants in North Alabama, namely, the Standard Portland Cement Co., located at Leeds in Jefferson County, and the Coosa Portland Cement Co., located at Ragland in St. Clair County. Both of these plants make use of the hard Trenton limestone, and the Standard Cement Co., according to Burchard of the U. S. Geological Survey, uses the shale of the Clinton formation whilst the Ragland Company makes use of the shales of the Coal Measures. Up to the present time no establishment is utilizing the Bangor limestone.

In Middle Alabama the soft, chalky Cretaceous limestone of the Selma Chalk, is the material utilized by the Alabama Portland Cement Co., at Spocari, near Demopolis. The same Company makes use of residual clays overlying and derived from the weathering of the Selma Chalk. During 1915 there was no production from the Demopolis plant.

In Southern Alabama the St. Stephens limestone outcropping east and west across the State, furnishes excellent material for Portland Cement manufacture, using either residual clays from decomposition of the limestone, or the clays of the Grand

Gulf formation which are almost everywhere in close proximity to the limestone.*

PUZZOLAN CEMENT.

Puzzolan or slag-lime cement was shipped during 1915 from plants at North Birmingham, Ala., Struthers, Ohio, and Sharon, Pa. The output in 1915 was 42,678 barrels, valued at $39,801, compared with 68,311 barrels, valued at $63,358, in 1914. This represents a decrease in quantity of 25,633 barrels, or nearly 38 per cent and in value of $23,557, or more than 37 per cent. The average price per barrel of Puzzolan cement in 1915 was about 93.3 cents, compared with 92.6 cents in 1914, an increase of 0.7 cent a barrel. The price of this cement, therefore, increased slightly in 1915, and was 7.3 cents higher than that of Portland cement. Puzzolan cement should command a good average price, for a considerable proportion of it is of light color, and nonstaining properties are claimed for it by the manufacturers.

The following table summarizes the number of active plants and the production of puzzolan cement produced during the last five years. Since 1912, inclusive, the quantities represent marketed production or shipments.

Statistics of the puzzolan cement industry, 1911-1915.

	1911	1912	1913	1914	1915
Number of plants reporting production:					
Alabama	1	1	1	1	1
New York†	1	1	1	1	....
Ohio	1	1	1	1	1
Pennsylvania	1	1	1	1	1
	4	4	4	4	3
Production in barrels	93,230	91,864	107,313	68,311	42,678
Total value	$77,786	$77,363	$97,663	$63,358	$39,801

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†Includes production of Collos cement, 1911-1914.

*Since recent investigations (quoted by Burchard), have shown that limestones containing as much as 10 per cent of magnesia, (MgO), may be used in the manufacture of Portland cement, without detriment to the quality of the cement, the quantity of limestone in Alabama suitable for this manufacture is very greatly increased, over former estimates.—E. A. S.

Owing to the fact that there was in Alabama in 1915 only one producer of puzzolan cement, and not more than two operating plants in the Portland cement industry, it is necessary to combine the productions of the two industries in order to avoid publishing figures which were given to the survey in confidence. The tabular results of such a combination are, however, necessarily inconsistent and not to be taken too literally, since the weights per barrel of the two kinds of cement vary.

The total quantity of Portland and puzzolan cement shipped to market in Alabama in 1915, was 1,114,386 barrels, valued at $891,473, as compared with 777,698 barrels in 1914, valued at $746,555, or an increase in quantity of 336,788 barrels or 43.31 per cent, and an increase in value of $144,918 or 19.41 per cent.

Below are presented in tabular form the foregoing figures:

Quantity and value of portland and puzzolan cement marketed in Alabama in 1914 and 1915.

	No. of Producers	Quantity (Bbls.)	Value.
1914	3	777,698	$746,555
1915	3	1,114,386	891,473
Increase		336,788	144,918
Per cent of Increase		43.31	19.41

In "Mineral Resources of the United States, for 1915. Part II, (pages 189-212)," the reader, who is interested in the subject, will find a very complete presentation of the cement industries of the United States, by Mr. E. F. Burchard of the U. S. Geological Survey.

RECOVERY OF POTASH FROM PORTLAND CEMENT MATERIALS.

The collection or elimination of dust in the cement plant is one of the most important problems in cement manufacture at present, and incidental to the study of this problem the year 1915 witnessed an awakening of interest on the part of several cement companies to the possibility of recovering potash as a by-product in cement manufacture. The pioneer in this field was the Riverside Portland Cement Co., the plant of which is at

Riverside, Cal. The operations at this plant have been mentioned by W. C. Phalen in recent chapters of Mineral Resources on potash salts. The early efforts of the Riverside company, which employs the Cottrell electrical precipitation process,[1] were directed rather toward precipitating waste dust than toward recovering potash, but the company soon discovered that, although the raw mix contained only about 0.2 per cent of potash, the dust contained potash in considerable quantities and a large portion of it is now being recovered. Since the supply of potash from Germany has been cut off the Riverside company has contracted for the sale of its potash at prices that yielded large returns on the investment for the dust-collecting equipment. The Western Precipitation Co., of Los Angeles, Cal., controls the license for all applications of the Cottrell precipitation process to cement manufacture.

The abnormally high prices for potash that have prevailed since the shortage began to be felt have, of course, stimulated many and diverse efforts to discover or devise a domestic source of potash, and the first plant in the East to follow the lead of the Riverside plant is that of the Security Cement & Lime Co., at Security, near Hagerstown, Md., where in May, 1916, the company's potash-recovery plant was rapidly nearing completion.

CLAY AND CLAY PRODUCTS.

CLAY.

JEFFERSON MIDDLETON AND EUGENE A. SMITH.

CLAY available for the manufacture of clay products is one of the most widely distributed of our minerals. Hence there are clay-working plants scattered over every State and Territory in the Union. Miners of the low-grade clays are usually also the manufacturers, but as the higher grades of ware are reached, the rule is that fewer and fewer manufacturers are also miners, until in the highest grades of ware the rule is that the manufacturer buys and does not mine the clay he uses. The figures given in the following tables represent clay that is mined and not manufactured by the miner, but is sold as clay. The clay thus sold is small in quantity compared with the total production and includes mainly clay used for high-grade pottery and tile, for paper making, and for refractory products.

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[1] For details of this process see Schmidt, W. A., Cottrell processes of electrical precipitation: Canadian Min. Inst. Trans., vol. 18, pp. 110-118, 1915.

The total amount of clay mined in Alabama and sold as such in 1915 was 31,870 short tons, valued at $35,232. This was an increase in quantity of 3,897 tons, or 13.93 per cent, and of $625, or 1.81 per cent in value as compared with 1914.

Below is a table giving the production and value of clay mined and sold in Alabama from 1908 to 1915 inclusive, and a comparison of the production of 1914 and 1915:

Production of clay in Alabama from 1908 to 1915 inclusive, and a comparison of the production in 1914 and 1915.

YEAR	Fire Clay		Miscellaneous Clay.		Total.	
	Quantity Short Tons	Value.	Quantity Short Tons	Value.	Quantity Short Tons	Value.
1908	68,289	$48,988	24,000	$12,000	92,289	$60,988
1909	45,137	35,345	18,271	5,587	63,408	40,932
1910	54,482	32,395	20,600	5,650	75,082	38,045
1911	35,208	29,909	....	....	35,208	29,909
1912	38,552	31,414	4,500	2,000	43,052	33,414
1913	49,901	53,269	*	*	49,901	53,419
1914	27,973	34,607	....	....	27,973	34,607
1915	31,520	34,882	*	*	31,870	35,232
Increase	3,547	275	....	....	3,897	625
Percentage	12.68	0.79	....	....	13.93	1.81

In 1914 the average value of Alabama fire clay was $1.23 per short ton, and the value of the Alabama product was 1.61† per cent of the total value of the fire clay produced in the United States. In 1915 the average value of the fire clay of Alabama was $1.11 per short ton, and the value of fire clay production of the State was 1.48 per cent of the total value of the United States production.

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*Not divulged but included in total.

†This was by mistake given at 0.92 in the 1914 Statistical Report.—E. A. S.

CLAY PRODUCTS.

The clay products of Alabama in 1915 were valued at $1, 193,022—brick and tile, $1,177,725; pottery, $15,297—a decrease of $381,001. Its principal clay product was common brick, valued at $382,092, or 32 per cent of the State total, a decrease of $256,754 from 1914. The quantity of common brick reported for 1915 was 70,681,000 brick, a decrease of 40,050,000 brick. Common brick was closely followed by vitrified brick or block, valued at $374,387, an increase of $125,862. The quantity of vitrified brick marketed in 1915 was 29,018,000 brick, an increase of 10,339,000 brick or block, Alabama ranked twenty-fourth in 1915 among the States in value of clay products, and 65 operators reported sales.

Jefferson County was the principal clay-working county, and reported a production valued at $815,338, or 68 per cent of the State's total value in 1915, a decrease of $213,797. Nearly all of the fire brick produced in the State comes from Jefferson County. Jefferson County is also the only producer of vitrified brick or block. The principal producing counties of common brick, named in the order of the value of output, were: Jefferson, Montgomery, Russell, and Talladega.

Clay products of Alabama, 1910-1915.

Product.	1910	1911	1912	1913	1914	1915
Brick:						
Common—						
Quantity	135,785,000	129,694,000	136,989,000	130,923,000	110,781,000	70,681,000
Value	$746,961	$708,903	$759,409	$730,148	$638,666	$382,092
Average per M	$5.50	$5.47	$5.54	$5.58	$5.77	$5 41
Vitrified—						
Quantity	19,772,000	21,444,000	26,480,000	24,183,000	18,679,000	29,018,000
Value	$236,516	$246,707	$353,303	$361,722	$248,525	$374,337
Average per M	$11.96	$11.50	$13.34	$14.96	$13.31	$12.90
Front—						
Quantity	(*)	9,169,000	10,629,000	(*)	(*)	5,815,000
Value	(*)	$128,403	$132,033	(*)	(*)	$58.212
Average per M	$15.96	$14.00	$12.42	$15.29	$11.42	$10.01
Fancy, value	....	(*)	(*)	....	(*)	....
Fire, value	$163,672	$193,375	$240,434	(*)	$167,021	$145,585
Draintile, value	$3,773	$3,777	$5,465	$10,802	$6,838	$9,330
Sewer pipe, value	(*)	(*)	(*)	(*)	(*)	(*)
Fireproofing, value	(*)	(*)	(*)	(*)	(*)	$62,114
Tile, not drain, value	....	....	....	(*)	....	....
Pottery:						
Red earthenware, value	$3,475	$11,243	$10,990	$11,164	$4,800	$6,741
Stoneware and yellow and Rockingham ware, value	$16,371	$14,753	$11,223	$8,994	$11,742	$8,556
Miscellaneous, value	$496,791	$639,941	$422,322	$968,751	$496,431	$146,055
Total value	$1,667,559	$1,947,102	$1,935,179	$2,091,581	$1,574,023	$1,193,022
Number of active firms reporting	87	82	74	68	70	65
Rank of State	22	17	17	16	20	24

*Included in "Miscellaneous."

Brick and Tile.

The total production of common brick in Alabama in 1915 was 70,681 M, valued at $382,092. This as compared with the 1914 production was a decrease of 40,040 M, or 36.16 per cent, and a decrease in value of $256,574 or 40.18 per cent.

In the case of vitrified brick there was an increase of 10,339 M, in quantity, or 55.35 per cent, and an increase in value of $125,862 or 50.64 per cent.

There was a decrease in the quantity of fire brick of 1,391 M, or 15.95 per cent, and in the value of $21,486 or 12.86 per cent.

The following tables give a review of the brick and tile industry of Alabama for the years 1914 and 1915:

Production of brick and tile in Alabama in 1915, not including pottery products.

Kinds.	Quantity Thousands	Value.	Av. price per M.	Per Cent of Total Value of Brick and Tile	Per Cent of Total U. S. Value.
Common brick	70,681	$382,092	$5.41	32.44	.91
Vitrified brick	29,018	374,387	12.90	31.79	3.06
Front brick	5,815	58,212	10.01	4.94	.61
Drain tile	....	9,330	....	.79	.15
Fire proofing	....	62,114	....	5.27	.81
Fire brick	7,330	145,535	19.85	12.36	.77
Miscellaneous	....	*146,055	....	12.40	3.93
Total	....	$1,177,725	....	100.00	0.94

*Includes sewer pipe, stove lining, silica brick, etc.

Brick and tile production in 1914 and 1915 compared.

Kind.	1914			1915			Increase or Decrease in Value.	Percentage.
	Quantity M	Value.	Average Price.	Quantity M	Value.	Average Price.		
Common brick	110,731	$638,666	$ 5.77	70,681	$382,092	$ 5.41	—256,574	40.18
Vitrified brick	18,679	248,525	13.31	29,018	374,387	12.90	+125,862	50.64
Front brick	*	*	*11.42	5,815	58,212	10.01	....	....
Drain tile	....	6,838	....	....	9,330	....	+ 2,492	36.40
Fire proofing	....	....	....	....	62,114	....	....	....
Fire brick	8,721	167,021	19.15	7,330	145,535	19.85	— 21,486	12.86
Miscellaneous	....	†496,431	....	....	†146,055	....	....	....

*Included in Miscellaneous. †Sewer pipe, stove lining, silica brick, etc.

POTTERIES.

The pottery industry of Alabama is of relatively small importance, as only the commoner and coarser grades of ware are produced and most of this for local trade only.

Production was reported in 1915 by 13 firms; the same as in 1914. The output was valued at $15,297, a decrease of $1,245 or 7.53 per cent. The products consisted of red earthen ware and stone ware only. The rank of Alabama in this industry for 1915, as for 1914, was 19.

Value of pottery products in 1915.

Kind.	Value.	Percentage of Total Alabama Pottery Products.	Percentage of Total U.S. Value.
Red earthenware	$6,741	44.06	0.63
Stoneware and Rockingham ware	8,556	55.94	0.37
Total	$15,297	100.00	.04

Comparison of pottery products in 1914 and 1915.

Kind.	1914	1915	Increase+ or Decrease—	Percentage.
Red Earthenware	$ 4,800	$ 6,741	+$1,941	40.44
Stoneware and Rockingham ware	11,742	8,556	— 3,186	27.13
Total	$16,542	$15,297	—$1,245	7.53

COAL.

E. W. PARKER AND C. E. LESHER.

INTRODUCTORY.

THE great Appalachian coal region which furnishes over two-thirds of the coal production of the United States and which extends from Ohio and Pennsylvania on the north in a gradually narrowing belt through eastern Kentucky and Tennessee has its southern terminus in a considerably broadened area that occupies a large part of the northern half of Alabama. The coal-bearing formations of Alabama underlie about 8,400 square miles and are divided into four distinct basins, the Coosa, the Cahaba, and the Warrior, named from the rivers which drain them, and the Plateau, which includes Blount, Lookout, and Sand or Raccoon Mountains. By far the most important basin in area and in production is the Warrior, which includes all of Walker County, most of Jefferson, Tuscaloosa, and Fayette counties, and smaller parts of Blount, Cullman, Winston and Marion counties. The area known to contain coal is approximately 4,000 square miles, or one-half the total coal area of the State, and contributes about 81 per cent of the total production.

There are several distinct coal groups in the basin, the most important of which are the Brookwood, the Pratt, and the Mary Lee, designated by the names of their principal beds. The Mary Lee group includes the Blue Creek, the Jagger, and the Newcastle beds, most of which are mined in places. The Brookwood, the Pratt, and the Mary Lee produce most of the coking coal mined in the State, and more than half of all of the coal mined in the district.

The Cahaba Basin, second in importance, is a long narrow syncline, 68 miles long and about 6 miles wide, southeast of the Warrior, and occupies parts of St. Clair, Jefferson, Shelby, and Bibb counties. There are many workable beds, and the total quantity of coal in the basin is large. The production is something over 18 per cent of the total for the State.

The Coosa Basin is a deep syncline east of the Cahaba and parallel with it, extending across Shelby and St. Clair counties. It is also long and narrow, 60 miles long by 6 miles wide. It has not been thoroughly explored, but in different parts of the area from two to twelve beds, 3 or more feet in thickness, have been reported.

The Plateau field embraces parts of Blount, Etowah, DeKalb, Cherokee, Marshall, and Jackson counties, and although it has an area underlain by coal four times that of the Cahaba and the Coosa combined, the resources in Alabama are comparatively small. There are four to six beds locally workable. So far as known, the earliest record of the existence of coal in Alabama was made in 1834. The first statement of production in the State is contained in the United States census report for 1840, in which year the production is given as 946 tons. The census report for 1850 does not mention any coal production for the State, and the next authentic record is contained in the census statistics of 1860, when Alabama is credited with an output of 10,200 short tons. The mines of Alabama were probably worked to a considerable extent during the Civil War, but there are no records of the actual production until 1870, for which year the United States census reports a production of 11,000 tons. Ten years later the production had increased to 323,972 short tons, but the development of the present great industry really began in 1881 and 1882, when attention was directed to the large iron deposits near the city of Birmingham and thus the great "boom" of that city and vicinity was inaugurated. By 1885 the coal production of the State had increased to nearly 2,500,000 tons. Then followed a period of relapse and liquidation, which lasted two years, after which business settled down to a conservative and rational basis and has since developed steadily. In 1902 the coal production of the State reached a total of more than 10,000,000 tons, and reached the maximum of 17,678,522 tons in 1913, since which time there has been a decrease.

PRODUCTION.

Total production in 1915, 14,927,937 net tons; spot value, $19,066,043. This represents a decrease of 665,485 tons, or 4 per cent, in quantity and of $1,783,876, or 9 per cent, in value compared with 1914. During the early part of the year many of the Alabama operators, less hopeful than the others, contracted for the sale of their output at lower prices than previously, with the result that the average value for the year decreased from $1.34 per ton in 1914 to $1.28 in 1915. The number of men employed decreased from 24,042 in 1914 to 22,591 in 1915 and the average number of days worked per man from 226 to 223. There was, however, no shortage of labor during the year.

The demand for Alabama coal was very light during the first half of 1915 and many mines were shut down. In August, however, marked industrial activity began, and the general resumption of operations by practically all the Alabama iron furnaces was a large factor in increasing the rate of production of coal toward the end of the year. Railroad and industrial activities were nevertheless below normal throughout the year, and the total output of coal was less than in any other period since 1909. In ordinary times Alabama supplies a large quantity of coal for steamship bunkers at Pensacola, Mobile, Gulfport, and New Orleans; but since the European war began there has been little call for coal for that purpose at those ports. The development of water power on a large scale in Alabama has also cut off the market for a large quantity of coal. The opening of Warrior River to navigation was expected to offer an outlet for large quantities of coal to New Orleans and Mobile ports, but in 1915 there was no demand from those sources and a comparatively small quantity of Alabama coal found markets over that waterway.

The statistics of the production of coal in Alabama in 1914 and 1915 are shown in the following tables:

Coal produced in Alabama in 1914 and 1915 (by counties).

1914

County.	Loaded at mines for shipment (net tons).	Sold to local trade and used by employees (net tons).	Used at mines for steam and heat (net tons).	Made into coke at mines (net tons).	Total quantity (net tons).	Total value.	Average value per ton.	Number of employees.	Average number of days worked.
Bibb	1,565,660	9,180	100,006	....	1,674,846	$ 2,576,057	$1.54	2,986	242
Blount	147,640	1,300	1,444	....	150,884	188,235	1.25	848	168
Etowah	153,402	1,293	2,214	....	156,909	222,289	1.42	279	241
Jefferson	6,515,079	46,527	292,071	1,082,468	7,936,145	10,486,552	1.32	11,843	236
St. Clair	726,132	1,816	24,640	....	752,588	978,196	1.30	896	229
Shelby	467,456	3,916	27,542	....	498,914	927,442	1.86	936	239
Tuscaloosa	428,387	13,355	59,562	357,595	858,899	1,177,473	1.37	1,491	226
Walker	3,037,567	51,284	112,704	248,630	3,450,185	4,124,863	1.20	5,416	199
Winston	31,035	525	58	....	31,618	46,787	1.48	101	248
Other counties*	73,496	1,704	5,841	....	81,041	119,496	1.47	246	187
Small mines	....	1,898	....	....	1,898	3,079	1.63	....	....
	13,145,854	132,798	626,082	1,688,693	15,593,422	$20,849,919	$1.34	24,042	226

***Cullman, Jackson, and Marion counties.**

1915

Bibb	1,420,639	8,359	105,536	....	1,534,534	$2,098,181	$1.36	2,628	235
Blount	163,018	1,021	1,700	....	165,739	226,716	1.37	368	189
Etowah	173,583	1,974	1,811	....	177,368	259,332	1.46	325	289
Jefferson	5,884,992	329,456	197,806	1,167,249	7,579,503	9,658,886	1.27	10,129	235
Marion	62,653	1,275	4,962	....	68,890	101,818	1.47	199	163
St. Clair	754,569	2,959	16,530	....	774,058	946,446	1.22	786	252
Shelby	550,594	3,290	35,528	....	589,412	989,580	1.68	1,058	227
Tuscaloosa	298,627	9,545	71,277	408,137	787,586	963,910	1.22	1,334	209
Walker	2,886,594	29,925	99,950	205,486	3,221,955	3,784,424	1.17	5,669	197
Winston	26,217	370	40	....	26,627	38,919	1.46	80	191
Small mines*	1,000	1,065	200	....	2,265	3,431	1.51	20	12
	12,222,486	389,239	585,340	1,780,872	14,927,937	$19,066,043	1.28	22,591	223

***Includes Jackson county.**

In the following table comparative statistics are given covering five years' annual production of coal in Alabama, by counties. The three counties of largest production, Bibb, Jefferson, and Walker, were all below the average for the 5-year period. In fact, both Bibb and Jefferson in 1915 had the lowest output in five years. Shelby County has shown consistent gains each year, and 4 counties out of 11 recorded increase in 1915.

Coal produced in Alabama, 1911-1915, in net tons (by counties).

County.	1911	1912	1913	1914	1915	Increase or decrease, 1915.
Bibb	1,633,197	1,781,335	1,911,026	1,674,846	1,534,534	— 140,312
Blount	82,266	146,342	178,958	150,384	165,739	+ 15,355
Cullman, Jackson, and Marion	(*)	131,505	123,615	81,041	†70,290	— 10,751
Etowah	255,860	171,308	137,792	156,909	177,368	+ 20,459
Jefferson	7,776,390	8,174,849	9,028,834	7,936,145	7,579,503	— 356,642
St. Clair	529,211	749,753	890,879	752,588	774,058	+ 21,470
Shelby	463,089	496,949	497,569	498,914	589,412	+ 90,498
Tuscaloosa	1,031,658	880,967	917,305	858,899	787,586	— 71,313
Walker	3,108,595	3,547,962	3,967,263	3,450,185	3,221,955	— 228,230
Winston	16,424	18,730	24,951	31,618	26,627	— 4,991
Small mines	*129,781	900	330	1,893	865	— 1,028
Total	15,021,421	16,100,600	17,678,522	15,593,422	14,927,937	— 665,485
Total value	$19,079,949	$20,829,252	$23,088,724	$20,849,919	$19,066,043	— $1,783,876

*Small mines include Cullman, Jackson, and Marion counties.
†No production in Cullman county.

The statistics of production in Alabama from 1840 to the close of 1915 are shown in the following table:

Production of coal in Alabama from 1840 to 1915 in short tons.

Year	Quantity	Year	Quantity	Year	Quantity	Year	Quantity
1840	946	1860	10,200	1880	323,972	1900	8,394,275
1841	1,000	1861	10,000	1881	420,000	1901	9,099,052
1842	1,000	1862	12,500	1882	896,000	1902	10,354,570
1843	1,200	1863	15,000	1883	1,568,000	1903	11,654,324
1844	1,200	1864	15,000	1884	2,240,000	1904	11,262,046
1845	1,500	1865	12,000	1885	2,492,000	1905	11,866,069
1846	1,500	1866	12,000	1886	1,800,000	1906	13,107,963
1847	2,000	1867	10,000	1887	1,950,000	1907	14,250,454
1848	2,000	1868	10,000	1888	2,900,000	1908	11,604,593
1849	2,500	1869	10,000	1889	3,572,983	1909	13,703,450
1850	2,500	1870	11,000	1890	4,090,409	1910	16,111,462
1851	3,000	1871	15,000	1891	4,759,781	1911	15,021,421
1852	3,000	1872	16,800	1892	5,529,312	1912	16,100,600
1853	4,000	1873	44,800	1893	5,136,935	1913	17,678,522
1854	4,500	1874	50,400	1894	4,397,178	1914	15,593,422
1855	6,000	1875	67,200	1895	5,693,775	1915	14,927,937
1856	6,800	1876	112,000	1896	5,748,697		
1857	8,000	1877	196,000	1897	5,893,770	Total	285,475,717
1858	8,500	1878	224,000	1898	6,535,283		
1859	9,000	1879	280,000	1899	7,593,416		

Coal produced in Alabama 1911-1915, and decrease in 1915.

Year	Quantity (net tons)	Value
1911	15,021,421	$19,079,949
1912	16,100,600	20,829,252
1913	17,678,522	23,083,724
1914	15,593,422	20,849,919
1915	14,927,937	19,066,043
Decrease, 1915	665,485	1,783,876
Percentage of decrease 1915	4.3	8.6

RANK OF COAL PRODUCING STATES.

The following tables give other details concerning the coal production in Alabama, including rank of the first ten coal producing states; labor statistics; strikes and suspensions; machines used; methods of mining, etc.:

Rank of first ten coal-producing States in 1914 and 1915, with quantity and value of products and percentage of each.

1914

Production				Value			
Rank	State or Territory	Quantity (short tons)	Percentage of total product'n	Rank	State or Territory	Value	Percentage of total value
1	Pennsylvania:			1	Pennsylvania:		
	Anthracite	90,821,507	17.7		Anthracite	$188,181,399	27.6
	Bituminous	147,983,294	28.8		Bituminous	159,006,296	23.3
2	West Virginia	71,707,626	14.0	2	West Virginia	71,391,408	10.5
3	Illinois	57,589,197	11.2	3	Illinois	64,693,529	9.5
4	Kentucky	20,382,763	4.0	4	Ohio	21,250,642	3.1
5	Ohio	18,843,115	4.0	5	Kentucky	20,852,463	3.0
6	Indiana	16,641,132	3.2	6	Alabama	20,849,919	3.0
7	Alabama	15,593,422	3.0	7	Indiana	18,290,928	2.7
8	Colorado	8,170,559	1.6	8	Colorado	13,601,718	2.0
9	Virginia	7,959,535	1.5	9	Iowa	13,364,070	2.0
10	Iowa	7,451,022	1.4	10	Kansas	11,238,253	1.6

1915

1	**Pennsylvania:**			1	**Pennsylvania:**		
	Anthracite	**88,995,061**	**16.8**		**Anthracite**	**$184,653,498**	**26.9**
	Bituminous	**157,955,187**	**29.7**		**Bituminous**	**167,419,705**	**24.4**
2	**West Virginia**	**77,184,069**	**14.5**	2	**West Virginia**	**74,561,849**	**10.8**
3	**Illinois**	**58,829,576**	**11.1**	3	**Illinois**	**64,622,471**	**9.4**
4	**Ohio**	**22,434,691**	**4.2**	4	**Ohio**	**24,207,075**	**3.5**
5	**Kentucky**	**21,361,674**	**4.0**	5	**Kentucky**	**21,494,008**	**3.1**
6	**Indiana**	**17,006,152**	**3.2**	6	**Alabama**	**19,066,043**	**2.8**
7	**Alabama**	**14,927,937**	**2.8**	7	**Indiana**	**18,637,476**	**2.7**
8	**Colorado**	**8,624,980**	**1.6**	8	**Colorado**	**13,599,264**	**2.0**
9	**Virginia**	**8,122,596**	**1.5**	9	**Iowa**	**13,577,608**	**2.0**
10	**Iowa**	**7,614,143**	**1.4**	10	**Kansas**	**11,360,680**	**1.6**

LABOR STATISTICS.

Statistics of labor employed in coal mines of Alabama 1908-1915.

Year	Number of days active	Average Number Employed
1908	222	19,197
1910	249	22,210
1911	227	22,707
1912	245	22,613
1913	255	24,552
1914	226	24,042
1915	223	22,591

Average production per man compared with hours worked per day, and average number of days worked 1910-1915.

Year	8 hours		9 hours		10 hours		All others	Total	Days Worked	Average Tonnage	
	Mines	Men	Mines	Men	Mines	Men	Men	Men		Per Year	Per Day
1910	13	766	36	2,633	134	17,306	1,525	22,230	249	725	2.91
1911	15	550	50	5,345	102	12,628	4,184	22,707	227	662	2.92
1912	11	338	46	4,145	107	13,938	4,192	22,613	245	712	2.91
1913	13	420	36	2,496	135	18,185	3,451	24,552	255	720	2.82
1914	14	646	24	3,546	150	18,115	1,785	24,042	226	648	2.87
1915	13	369	44	4,402	133	17,109	711	22,591	223	661	2.96

Statistics of labor strikes in the coal mines of Alabama in 1914 and 1915.

1914			1915		
Number of men on strike	Total days lost	Average number of days lost per man	Number of Men on strike	Total days lost	Average number of days lost per man
320	3,940	12	175	1,290	7

Ra

Rank

DISTRIBUTION AND CONSUMPTION.

C. E. LESHER.

OBJECT AND SCOPE OF REPORT.

THE object of this report is to furnish statistics showing the internal distribution of the coal produced in the United States, the principal purposes for which it is used, and the quantities consumed in each State. For 34 years the Geological Survey has collected and published the statistics of the production and value of coal, but this is the first comprehensive investigation made to show in detail where the coal produced is consumed. The competition between the bituminous coal-producing districts in the United States for the domestic markets is as active as that between the coal-exporting nations of the world for the foreign markets. The extent and nature of the demand in the domestic markets are moreover of ever-present interest to our coal industry, because more than 95 per cent of the coal produced in the United States is used within the country.

The largest problem confronting the exploiters of a coal deposit is, of course, that of markets, and whoever produces or sells the coal must consider in a broad way the possible markets not only as to quantity but as to quality. For blacksmithing and for making coal gas, coals that have special chemical properties are required, and domestic users have established preferences based on both experience and prejudice. By far the largest part of the coal supplied to every market is used for raising steam, and the statistics of coal used for this purpose in any and every part of the country are therefore of primary interest to those who are engaged in the coal industry. The limitations of time and funds available for the work on this report have permitted only incidental consideration of the markets for bituminous coals of particular kinds. The distribution of coal from West Virginia, for instance, is shown for the State as a unit, though there is a great difference between the kinds of coal mined there and as great a difference between the markets reached by the coal.

COAL MINED BY MACHINES IN ALABAMA.

Bituminous coal mined by machines in Alabama in 1914 and 1915.

Year	Number of machines in use	Number of tons mined by machines	Total tonnage of Alabama	Percentage of total product mined by machines
1914	362	4,937,222	15,593,422	31.7
1915	373	5,285,133	14,927,937	35.4

Quantity and percentage of coal mined by different methods in Alabama in 1914 and 1915, short tons.

Year	Mined by hand	Percentage	Shot off the solid	Percentage	Mined by machines	Percentage	Not reported	Percentage	Total production
1914	5,134,787	32.9	5,498,988	35.3	4,937,222	31.7	22,425	.14	15,593,422
1915	4,634,815	31.0	5,001,658	33.5	5,285,133	35.4	6,336	.04	14,927,937

COAL WASHING OPERATIONS.

Coal washed at the mines in Alabama in 1914 and 1915, with quantity of washed coal and of refuse obtained from it, short tons.

Year	Quantity of coal washed	Quantity of cleaned coal	Quantity of refuse
1914	7,913,030	7,081,868	831,162
1915	8,734,475	7,920,122	814,353

AVERAGE VALUE OF ALABAMA COAL.

Average value per short ton for coal at the mines in Alabama since 1908.

1908	1909	1910	1911	1912	1913	1914	1915	Decline in 1915
$1.26	$1.19	$1.26	$1.27	$1.29	$1.31	$1.34	$1.28	$0.06

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The cost of mining, the largest element of which—the cost of labor—is now practically controlled either directly or indirectly by the labor unions, and the cost of transportation, regulated by the Government through the Interstate Commerce Commission, impose definite limitations upon the markets that may profitably be reached by any coal. It is fast becoming the rule that the deciding factor in the purchase of coal for most uses is its cost in terms of the work to be performed.

Statistics of the movement of coal to market are of particular interest to those who are considering railroad rates. The quantity of coal carried by the railroads is larger than that of any other single commodity, and it is the coal traffic that has made possible the profitable operation of a number of important railroads. It is to the interest of the coal-carrying roads, within the limits of fair play, to keep in balance the movement from the competing fields. Here, again, data of the kind given in this report are needed as a basis of intelligent action.

DISTRIBUTION OF COAL PRODUCED IN ALABAMA IN 1915.

IN ITS output of coal Alabama is the most productive State in the South, and it is centrally located as regards the markets of the Southern States. In 1915 the southern railroads used nearly 5,000,000 tons of Alabama coal, which is 32 per cent of the production in Alabama and nearly 23 per cent of the consumption by the railroads in the South. About 200,000 tons of coal from Alabama was used by railroads west of Mississippi River. In addition to that taken by the railroads, more than 7,300,000 tons, or nearly half the total output, was used in the State; 2,000,000 tons, or 13.5 per cent of the output, was shipped to other States; and 500,000 tons, or 3.5 per cent, went to tidewater for foreign and domestic cargo and bunker fuel. Of the coal shipped outside the State for commercial use the greater part, about 1,500,000 tons, reached the Mississippi Valley markets in Louisiana and Mississippi and in a less amount those in Missouri, Tennessee, and Arkansas. On the east, Georgia and Florida are the best consumers of Alabama coal.

Competition by coal from the fields to the north; particularly those of southern Illinois and western Kentucky, restricts the expansion of markets for coal from Alabama in the Mississippi Valley and at New Orleans. Similar competition on the east by coal from Virginia, Kentucky, and Tennessee meets coal from Alabama in the markets of the Carolinas and Georgia. The higher grades of Alabama coal are sent in small shipments to markets as distant as the Pacific coast. The tidewater business at southern Atlantic ports (except Hampton Roads) and at gulf ports is not very large as compared with that at the northern ports, and in 1915 it was below normal. About 500,000 tons of coal from Alabama reached tidewater in 1915.

Coal shipped to tidewater points from Alabama in 1915, in net tons.

Port.	Quantity	Use.	Quantity
Mobile, Ala.	103,320	Foreign export	23,641
Pensacola, Fla.	145,369	Foreign bunker	319,307
New Orleans, La.	116,205	Domestic bunker	160,951
South Carolina ports	11,904		
Georgia ports	127,101		
	503,899		503,899

Distribution of coal mined in Alabama in 1915.

	Quantity (net tons)	Percentage of total
Used in Alabama		
Used at mines for steam and heat	535,340	
Sold to local trade, not shipped	289,239	
Made into coke at mines	1,780,872	
Shipped to Alabama points	4,742,435	
Total used in Alabama	7,347,886	49
Shipped to other States:		
Arkansas	10,450	
California	292	
Florida	108,782	

Distribution of coal mined in Alabama in 1915.—Continued.

	Quantity (Net tons).	Percentage of total.
Georgia	363,572	
Louisiana	717,437	
Mississippi	596,218	
Missouri	3,519	
North Carolina and South Carolina	475	
Oklahoma	713	
Oregon	190	
Tennessee	161,754	
Texas	39,987	
Virginia	307	
Washington	21	
Total shipped to other States (all rail)	2,003,717	14
Shipped to tidewater	503,899	3
Used by railroads:		
Loaded at mine tipples	100,000	
Shipped	4,972,435	
Total used by railroads	5,072,435	34
Total production	14,927,937	100

Shipments of bituminous coal in Alabama, by railroads and waterways, in 1915.

Route	Quantity net tons
Railroad	
Alabama Great Southern	51,507
Atlanta, Birmingham and Atlantic	180,859
Birmingham Southern	2,390,482
Central of Georgia, Alabama and Georgia	788,716
Frisco (includes Alabama Central, Birmingham Belt, and B. R. L. & P. (Huntingdon)	1,793,672
Illinois Central	95,553
Louisville & Nashville (includes Warrior Mineral)	3,229,139
Mobile and Ohio	309,162
Nashville, Chattanooga & St. Louis, Alabama and Tennessee coal combined	1,068,870
Southern (includes Northern Alabama)	2,895,131
Seaboard Air Line, Thomas & Sayreton	380,255
Waterway—Warrior River	169,618

Consumption of coal produced in 1915, by uses.

Uses	Quantity (net tons)	Percentage of total Ala. Production
Railroad fuel	5,072,485	34.0
Steamship bunker fuel, tidewater	480,258	3.2
Manufacture of bee-hive coke	1,708,228	11.4
Manufacture of by-product coke	2,987,710	20.0
Manufacture of coal gas	109,160	.8
Domestic and small steam trade	1,592,932	10.7
Industrial steam trade	2,389,397	16.1
Exported	23,641	.1
Used at mines for steam and heat	535,340	3.6
Special uses, blacksmithing mainly	28,836	.1
Total	14,927,987	100.0

Coal consumed in Alabama in 1915, according to source.

(Exclusive of fuel for railroads and steamships.)

Source	Quantity Net Tons
Alabama	7,347,836
Georgia	88
Kentucky	56,913
Tennessee	48,942
Virginia	67,961
West Virginia	2,800
Total bituminous coal	7,524,540
Pennsylvania anthracite	8,100
	7,532,640

COKE.

C. E. LESHER AND EUGENE A. SMITH.

INTRODUCTION.

THE production of coke in Alabama decreased from 3,084,149 short tons valued at $8,408,443 in 1914, to 3,071,811 tons valued at $8,545,555 in 1915. The decrease was 12,338 tons, or .4 per cent in quantity, and an increase of $137,112 or 1.6 per cent in value. There were in Alabama in 1915, 4 retort oven establishments with a total of 750 ovens, and these four establishments produced 2,070,334 tons or nearly 67 per cent of the total output, whereas 18 active beehive plants with an aggregate of 2,506 ovens in blast, produced 1,001,477 tons, or a little more than 33 per cent of the total. The average production per oven in the by-product plants was 2,760 tons and the average production from active beehive ovens was 300 tons. The increase in the production of by-product coke in 1915 over 1914 was 38,799 tons or 1.9 per cent, and the decrease in the production of beehive coke was 51,137 tons or 4.9 per cent. The value of the by-product coke, showed an increase of $380,000, or 7.5 per cent. The average yield of coal in coke from the retort ovens was 69.3 per cent, and the average yield in the beehive ovens was 58.6 per cent. There is not the marked difference in the values of retort and beehive cokes (and in favor of the former) in Alabama as is shown in some states, for in Alabama the retort ovens, like the beehive, are located near the mines, and the two in that respect are somewhat on a parity, whereas in most of the states in which retort coke is made the ovens are at a considerable distance from the mines, and the transportation charges assessed against the coal appear in the cost of the coke to the consumer. In fact, Alabama beehive coke had a higher value per ton in 1915 than the retort coke, the average being for the beehive $3.08 and for the retort coke, $2.64. The explanation of this seeming inconsistency lies in the fact that all of the retort coke is used by the producers in their own furnaces, and the coke is charged to the furnaces at little more than cost, whereas the greater part of the beehive product is commercial coke, some of it for foundry use, and profits are included in the value.

That the beehive has had its day in Alabama and is on the decline is evidenced by the fact that no new ovens of that type have been built in the last six years, and that 20 establishments with a complement of 4,734 ovens out of a total of 38 establishments with 8,568 ovens were idle in 1915 not counting the idle ovens at plants producing some coke in 1915.

The number of retort ovens increased from 620 in 1912 and 700 in 1913 to 750 in 1914 and 1915. The 750 completed ovens included 300 Semet-Solvay and 450 Koppers ovens. There were no new ovens under construction at the close of 1915.

PRODUCTION AND CONSUMPTION.

The production of coke in Alabama in 1880, 1890, 1900 and annually from 1910 to 1915 is shown in the following tables:

Statistics of the manufacture of coke in Alabama, 1880-1915.

Year	Establishments	Ovens		Coal used (short tons)	Yield of coal in coke (per cent)	Coke produced (short tons)	Total value of coke at ovens	Value of coke at ovens, per ton
		Built	Building					
1880	4	316	100	106,283	57.0	60,781	$ 183,063	$3.01
1890	20	4,805	371	1,809,964	59.0	1,072,942	2,589,447	2.41
1900	30	6,529	690	3,582,547	58.9	2,110,837	5,629,428	2.67
1910	48	10,132	340	5,272,322	61.6	3,249,027	9,165,821	2.82
1911	44	10,121	280	4,411,298	62.6	2,761,521	7,593,594	2.75
1912	46	10,208	100	4,585,498	64.9	2,975,489	8,098,412	2.72
1913	46	10,284	20	5,218,328	63.6	3,323,664	9,627,170	2.90
1914	38	*†9,318	0	4,678,196	65.9	3,084,149	8,408,443	2.73
1915	38	*9,318	0	4,695,938	65.4	3,071,811	8,545,555	2.78

*Includes 300 Semet-Solvay and 450 Koppers ovens.

†In 1914 Report the number of ovens was given at 9,285 on account of 33 ovens not being included in the total.

Comparison of the production and value of coke in Alabama in 1914 and 1915.

	Number of ovens	Coal charged (short tons)	Coke produced (short tons)	Total value of coke at ovens	Percentage of total U.S. value
1914	*9,318	4,678,196	3,084,149	$8,408,443	9.52
1915	9,318	4,695,938	3,071,811	8,545,555	8.10
Increase or decrease	+ 33	+ 17,742	— 12,338	+ 137,112	....
Percentage	.3	.4	.4	1.6	....

*The 1914 Bulletin gave this number as 9,285, due to an omission of 33 ovens.

Coke produced in beehive and by-product ovens in Alabama in 1914 and 1915.

Year	Beehive coke				By-product coke				Total		
	Active ovens	Coal used (net tons)	Coke produced (net tons)	Value of coke at ovens	Active ovens	Coal used (net tons)	Coke produced (net tons)	Value of coke at ovens	Coal used (net tons)	Coke produced (net tons)	Value of coke at ovens
1914	2,562	1,768,848	1,052,614	$3,329,606	750	2,909,348	2,031,535	$5,078,837	4,678,196	3,084,149	$ 8,408,443
1915	2,506	1,708,228	1,001,477	3,086,656	732	2,987,710	2,070,334	5,458,899	4,695,938	3,071,811	8,545,555
Increase or decrease	— 60	— 60,620	— 51,137	— 242,950	— 18	+ 78,362	+ 38,799	+ 380,062	+ 17,742	— 12,338	+ 137,112
Percentage	2.3	3.4	4.9	7.3	2.4	2.7	1.9	7.5	0.4	0.4	1.6

Coke consumed in Alabama in 1915, in net tons.

State	Furnace	Foundry
Alabama	2,869,268	108,003
Georgia and Tennessee	....	2,696
Virginia and West Virginia	1,110	202
Totals	2,870,378	110,901

VALUE.

Quantity (net tons) and value of coke produced in Alabama, 1912-1915.

	1912	1913	1914	1915	Increase or decrease	Percentage		
						Total	Beehive	By-product
Quantity	2,975,489	3,323,664	3,084,149	3,071,811	— 12,338	—0.4	—4.9	+1.9
Value	$8,098,412	$9,627,170	$8,408,443	$8,545,555	+$137,112	+1.6	—7.3	+7.5

Average value, per short ton and percentage yield of coke from coal, in Alabama, 1911-1915.

	1911	1912	1913	1914	1915
Average value	$2.75	$2.72	$2.90	$2.73	$2.78
Percentage yield	62.6	64.9	63.6	65.9	65.4

Quantity and value of coal used in the manufacture of coke in Alabama in 1914 and 1915, and quantity and value of same per ton of coke.

Year	Coal used (short tons)	Total value of coal	Value of coal per ton	Quantity of coal per ton of coke (short tons)	Value of coal to a ton of coke
1914	4,678,196	$6,765,639	$1.45	1,517	$2,200
1915	4,695,938	6,955,215	1.48	1,529	2,263

Coke Ovens.

Coke ovens in Alabama, 1914 and 1915.

Year	Active		Idle		Total		Abandoned	
	Beehive	By-product	Beehive	By-product	Beehive	By-product	Beehive	By-product
1914	2,562	750	*6,006	0	*8,568	750	1,049	......
1915	2,506	782	6,062	18	8,568	750	......	......

*In 1914 Bulletin, these numbers were 33 less due to an omission of 33 idle ovens.

Coke ovens in Alabama at the end of 1911-1915.

Year	Beehive	By-product
1911	9,781	340
1912	9,588	620
1913	9,584	700
1914	8,568	750
1915	8,568	750

Record of by-product ovens in Alabama, 1910-1915.

Year	Built	Building
December 31, 1910	280	340
December 31, 1911	340	280
December 31, 1912	620	100
December 31, 1913	700	20
December 31, 1914	750	0
December 31, 1915	750	0

Complete list of retort coke-oven plants of Alabama, Jan. 1, 1916.

Town	System	Name of company owning plant	Number of installments	Date put in operation	Number of ovens	Uses of coke	Uses of surplus gas
Ensley (near Birmingham)	Semet-Solvay	Tennessee Coal, Iron & R. R. Co.	First	October, 1898	120	Blast furnace	Fuel.
			Second	March, 1902	120	Blast furnace	Fuel.
Tuscaloosa	Semet-Solvay	Central Iron & Coal Co.	First	February, 1906	40	Blast furnace	Fuel.
Tuscaloosa	Semet-Solvay	Central Iron & Coal Co.	Second	1914	20	Blast furnace	Fuel.
Woodward	Koppers	Woodward Iron Co.	First	1911	60	Blast furnace	Fuel and power.
Woodward	Koppers	Woodward Iron Co.	Second	1913	80	Blast furnace	Fuel and power.
Woodward	Koppers	Woodward Iron Co.	Third	1914	30	Blast furnace	Fuel and power.
Fairfield	Koppers	Tennessee Coal, Iron & R. R. Co.	First	1912	280	Blast furnace	Fuel and power.

CHARACTER OF THE COAL USED.

Ninety-five and six-tenths per cent of the coal used in the manufacture of coke in Alabama is washed before being charged into the ovens. In 1915 out of a total of 4,695,938 tons of coal made into coke, 4,490,397 tons were washed. Of the washed coal used, 2,968,248 tons were slack and 1,522,149 tons were mine run.

The unwashed mine run coal was 158,480 tons, the unwashed slack was 47,061 tons in 1915.

The character of the coal used in the manufacture of coke in Alabama in 1890, 1900, and for the last six years is shown in the following tables:

Character of coal used in the manufacture of coke in Alabama, 1890-1915, in short tons.

Year	Run of Mine		Slack		Total
	Unwashed	Washed	Unwashed	Washed	
1890	1,480,669	0	206,106	123,189	1,809,964
1900	1,729,882	152,077	165,418	1,535,170	3,582,547
1910	771,931	1,308,085	0	3,192,306	5,272,322
1911	693,135	1,295,109	2,937	2,420,117	4,411,298
1912	747,305	896,421	18,793	2,922,979	4,585,498
1913	863,659	684,223	0	3,665,441	5,213,323
1914	703,241	2,069,638	0	1,905,317	4,678,196
1915	158,480	1,522,149	47,061	2,968,248	4,695,938

Character of coal used in the manufacture of coke in Alabama in 1914 and 1915, in short tons.

Year	Run of mine		Slack		Total			
	Unwashed	Washed	Unwashed	Washed	Unwashed	Percentage	Washed	Percentage
1914	703,241	2,069,638	0	1,905,317	703,241	15.0	3,974,955	85.0
1915	158,480	1,522,149	47,061	2,968,248	205,541	4.4	4,490,397	95.6

RANK OF COKE-PRODUCING STATES.

Coke was produced in 1915 in 22 States; in 5 States only beehive ovens were used; in 10 the whole product came from by-product ovens; and in 7 States both methods of coke making were employed. In total output Pennsylvania heads the list, with Alabama, Indiana, and Illinois following in order. The same States rank highest as regards production from by-product ovens, Indiana, however, leading Alabama in that respect. The rank of the coke-producing States in respect of total and of by-product output for the years 1911-1915 is shown in the following table. Michigan, Ohio, and New York moved up from ninth, eleventh, and twelfth place, respectively, in 1914, to sixth, seventh, and eighth in 1915, by reason of the increased output of by-product coke.

Rank of the States in the production of coke, 1911-1915.

State	1911		1912		1913		1914		1915	
	Total	By-product	Total	By-product	Total	By-product	Total	By-product	Total	By-product
Pennsylvania	1	1	1	1	1	1	1	1	1	1
Alabama	2	5	2	4	2	3	2	3	2	3
Indiana	6	3	3	2	3	2	3	2	3	2
Illinois	4	2	5	3	5	4	4	4	4	4
West Virginia	3	12	4	12	4	12	5	14	5	13
Michigan	12	8	11	8	11	8	9	6	6	5
Ohio	15	11	13	11	14	11	11	9	7	7
New York	8	4	8	5	8	5	12	8	8	6
Colorado	5	....	6	....	7	....	7	....	9	....
Virginia	7	....	7	....	6	....	6	....	10	....
Wisconsin	9	6	9	6	9	6	8	5	11	8
Kentucky	19	....	18	....	16	14	18	11	12	12
Massachusetts	10	7	10	7	10	7	10	7	13	9
New Mexico	11	....	12	....	12	....	14	....	14	....
Utah	17	....	15	....	15	....	15	....	15	....
Maryland	18	9	16	9	18	10	19	13	16	10
New Jersey	16	10	17	10	17	9	17	10	17	11
Tennessee	14	....	14	....	18	....	16	....	18	17
Washington	20	....	20	....	20	....	20	15	19	16
Missouri	....	....	....	....	....	....	....	....	20	14
Minnesota	18	13	19	13	19	13	18	12	21	15
Georgia	21	....	21	....	21	....	21	....	22	....
Kansas	22	....	22	....	....	....	....	....	....	....

GOLD AND SILVER.

J. P. Dunlop and J. M. Hill.

THERE does not appear to be any record of the first mining in Alabama, but it probably dates from about 1830 or shortly after the gold excitement commenced in Georgia. The estimated production up to 1879 was $365,300, and the yearly output from 1880 to 1903 varied from $1,000 to $8,000 a year. Alabama, unlike most other Southern States, has made its greatest production in recent years from 1904 to 1910, from deep mines, including the Hog Mountain in Tallapoosa County and the Storey in Talladega County.

In 1915 there were mined in Alabama 253.63 ounces of gold, valued at $5,243, and 12 ounces of silver, valued at $6.

The following table shows the mine production of gold, silver, and copper in Alabama since 1905, when the United States Geological Survey first collected detailed figures from the mines of the Eastern States:

Tonnage of ore treated and output of metals in Alabama, 1905-1915.

Year	Ore sold or treated Short tons	Gold*	Silver* Fine ounces	Copper pounds	Total value
1905	16,425	$41,580	336	....	$41,733
1906	8,565	24,921	124	....	25,004
1907	18,400	25,982	439	84,678	43,208
1908	11,174	41,208	282	....	41,357
1909	9,886	29,239	212	....	29,349
1910	9,763	33,583	268	....	33,678
1911	6,360	18,916	171	....	19,007
1912	5,693	16,724	168	....	16,827
1913	4,068	11,094	117	....	11,165
1914	5,079	11,970	199	....	12,080
1915	1,250	5,243	12	....	5,249
Decrease in 1915	3,829	6,727	187	....	6,831
Percentage	76.4	56.2	93.9	....	56.5

*Includes placer gold and silver.

The decrease is due to the closing of the Hog Mountain mines, in Tallapoosa County, which for several years produced most of Alabama's gold and silver. There was very little placer mining during 1915, only a nominal output of placer gold being reported to the Survey. Some prospecting was done on the placer deposits near Arbacoochee, in Cleburne County, but it resulted in no extensive development. The dredge installed there two years ago has been dismantled. Near Chula Finne there was some prospecting for gold quartz. Placer gold was found in a branch on the Tucker farm, 2 miles east of Heflin, and a little sluicing was done in June. The Story mine in Talladega County was operated by the Gold Log Mining Co. The ore is treated in a 10-stamp amalgamating mill.

In the vicinity of Arbacoochee the old placer workings covered a narrow area about 3 miles from east to west along Mud Creek. Much of the work done was on shallow, hillside wash. The material worked was angular quartz carried in a red clay; it is entirely local. The gold in the form of irregular angular nuggets and flakes was evidently derived from the numerous small quartz stringers in the saprolitic schists, and the concentration was practically in place. A little gold was carried into the bed of Mud Creek, which has been worked to the junction with Clear Creek. Clear Creek, so far as could be learned, has not been prospected, though it heads in Turkey Heaven Mountain, in which there are known to be auriferous lodes. It would seem that the saprolite deposits east of Arbacoochee should be tested and that drilling in the angular quartz gravels of Clear Creek, both above and below the mouth of Mud Creek. might reveal workable dredge ground. Above the mouth of Mud Creek the Clear Creek gravels appear to be relatively thin, ranging from 3 to 8 feet thick; below the mouth of Mud Creek the valley widens to about 1 mile and the gravels appear to be deeper. It is said that at the dredge there was 16 feet of gravel and most of the gold was concentrated in the lower 2 or 3 feet. Angular quartz fragments from 2 to 8 inches constitute about 85 per cent of the gravel, the remainder being rather soft schist and slate. This condition is brought about by the soft altered condition of most of the rocks in the vicinity.

GRAPHITE.

By Edson S. Bastin.

Introduction.

THE form of carbon known as graphite or plumbago occurs in nature in a variety of ways and serves many useful purposes, especially in the manufacture of crucibles and other refractory products, in lubricants, as foundry facings, and in stove polishes. Its properties, origin, uses, and mode of occurrence at the principal localities of the United States have been fully described in the report on graphite in Mineral Resources for 1913, which will be sent free on request to the Director, United States Geological Survey, Washington, D. C. That report also contains a bibliography of the more important publications dealing with the general character of graphite and its occurrence in this country.

Because of its use in the manufacture of crucibles, graphite is a mineral resource of vital importance in time of war. The effect of the European war upon the graphite industry in this country in 1915 is very interesting and will be discussed at some length in another part of this chapter. In general the industry was greatly stimulated by the increased demands for graphite products, particularly crucibles, and many American producers of flake graphite reported greatly increased production. Most crucible makers largely increased their output, though unable to take full advantage of the increased demand because of the difficulty in obtaining adequate supplies of graphite of crucible grade. In the mining and concentration of flake graphite particular activity was displayed in Alabama, where one new plant, built in 1914, became an important producer in 1915, and where three new properties are being opened but have not yet reached the producing stage.

Production.

As usual, the greater part of the crystalline graphite was produced by New York, Pennsylvania, and Alabama. The production of these States was all of the variety known in the trade as "flake' graphite, which occurs as small flakes forming

5 to 10 per cent, by weight, of crystalline schists, from which it is separated by more or less complicated milling processes. In addition, a small quantity of crystalline graphite, resembling in a general way the Ceylon graphite, was produced in Montana. As a result of increased production in all these States, but particularly in Alabama, the quantity of crystalline graphite produced in 1915 exceeded that for any previous year. The number of producers of crystalline graphite were 4 in Alabama, 1 in Montana, 3 in New York, and 2 in Pennsylvania.

Four firms produced graphite in Alabama in 1915, the Alabama Graphite Co., the Quenelda Graphite Co., and the Jennings Graphite Co., all near Ashland, in Clay County, and the Flaketown Graphite Co., near Mountain Creek, in Chilton County. The Jennings Graphite Co. began operation late in 1914 and reported an important production in 1915. Its mine is 4 miles west of Lineville; its mill is equipped with an electrostatic separator.

Three new companies have recently begun operations near Ashland, but marketed no graphite during 1915. The Clay County Graphite Co. (Inc.) has a mine and a mill 2 miles north of Ashland. The mill began operation in March, 1916. The Standard Graphite Co., whose office is at Ashland, is developing a graphite property 8 miles west of that place. A mill is in process of erection and the property is expected to begin producing about the middle of 1916. The third company is known as the Southern Graphite Co.; its mine is about 3 miles northwest of Ashland and its mill is now (March, 1916) under construction.

The following table gives a comparison of the production and value of graphite in Alabama in 1914 and 1915:

Production and value of crystalline graphite in Alabama in 1914 and 1915.

	Quantity, pounds	Value	Percentage of total U. S. quantity	Percentage of total U. S. value
1914	2,410,200	$118,000	27.79	*36.41
1915	3,474,800	204,572	36.81	47.61
Increase in 1915	1,064,600	86,572		
Percentage	44.2	78.4		

*This is Alabama's proportion of the total U. S. value of graphite (amorphous and crystalline), while Alabama's proportion in 1914 represents 41.85 per cent, in 1915 49.02 per cent of the total U. S. value of crystalline graphite.

GEOLOGY AND DISTRIBUTION OF GRAPHITE IN ALABAMA.

By **Wm. F. Prouty**, Geological Survey of Alabama.

THE crystalline or flake graphite deposits of Alabama are best developed in a comparatively narrow belt extending in a general northeast-southwest direction through portions of Cleburne, Clay, Coosa and Chilton counties.

There are two well marked divisions of this belt. The one to the northeast extends from the extreme northeast corner of Clay county for about 27 miles in a southwesterly direction past Delta, Pyriton, Ashland, to a line drawn from Coleta to Millersville. This area widens toward the southwest.

Between Millerville and Goodwater the flake graphite seems to be largely absent.

The second well-defined belt of flake graphite begins at about Goodwater, in Coosa county, and extends at first to the northwest, thence in a westerly direction, gradually changing to the normal southwest direction through Coosa county between Weogufka and Hanover, past Dollar and Coosa river some five miles, into Chilton County. The graphite rocks probably extend considerably further in the same direction but they are completely concealed by the unconsolidated sands and clays of the cretaceous formation.

The length of the southwest division from Goodwater to a little north of Verbena and Mountain Creek, where it becomes lost under the later sediments, is approximately 33 miles. The area thus has a total length of outcrop, exclusive of the 10-mile strip between Millerville and Goodwater, of about 60 miles. The area has a maximum width, in both divisions, of about four miles.

The area thus defined includes practically all of the known important flake graphite deposits. Occurrences in other areas to the east of this belt have been noted, but they seem to be local developments and, as a rule, rather low in graphite.

The belt is also known to continue to the northeast through Cleburne County and on into Georgia. It is very possible that portions of this belt may prove to have workable ore, but at the present time such deposits are not known to the author.

The rock in which the flake graphite beds occur is a mica schist, generally considered of pre-Cambrian age, for the most part highly metamorphosed and much intruded by both acid and basic igneous rocks, which are for the most part in long dikes, nearly parallel with the trend of the graphite ore bodies but in some cases cutting them at small angles. Some of the pegmatite dikes have excellent commercial mica and kaolin. Bordering this mica schist on the west, for the entire length of the area, occurs a green colored schist, originally a basic igneous rock and designated by the Alabama Geological Survey the Hillabee schist. The graphite area is seldom more than three miles distant from this metamorphosed basic igneous mass, and locally is in contact with it. The gap in the graphitic area between Millerville and Goodwater is in part due to the extension of the above-mentioned igneous mass into this portion of the field and the cutting out of the mica schist.

The effect of these igneous masses on the associated rocks is in some cases very marked. Secondary minerals of the nature of garnets are often very common bordering the basic intrusions, while muscovite mica occurs frequently in much larger amounts on the border of the granite intrusions.

The number of graphite beds varies greatly in different parts of the field. In portions of the area there are probably more than 15 distinct parallel graphite leads. In some portions of the field these beds are more or less well developed and continuous but elsewhere the beds change rapidly in their character for short distances along the strike. A good workable bed may fall off in graphite content for the whole width of the bed, or the bed may narrow and become too thin to work, or a parting or several partings composed of mica schist, massive quartz or igneous dikes may split the otherwise thick bed into several thin ones, all of which may be too thin to work profitably. The workable portion of some of the beds is, in a number of cases, more than 100 feet thick, but for the most part the workable beds are much thinner, 20 to 60 feet being a common thickness. It is not probable that any of the beds are continuous throughout the entire length of the field, but at different localities in about the same horizon, enrichments of graphite occur which vary considerably in their continuity and value.

Beds Not Evenly Spaced.

The beds of graphite are by no means evenly spaced but occur in fairly well defined groups. The intervening mica schists may have a considerable thickness free from graphite.

While it is not always possible to identify any one particular bed of graphite in different parts of the field, it is usually possible to identify the group to which the bed belongs.

It is concluded from the nature of the occurrence of the graphite beds that they are of sedimentary origin and that the carbonaceous deposits have been charged by metamorphism into the flake graphite deposits. It is noticeable that this metamorphism has been in some cases heightened by the igneous dikes. Frequently the better grade ore is near such masses.

The average content of the workable graphite ore is considerably less than 5 per cent, which is so often mentioned in literature as being the grade of the Alabama ores. A grade of 3.5 per cent seems to be a good average ore. Some deposits with as much as 5 per cent graphite would not pay to work on account of the flake being too small. The larger and firmer the flake, other things being equal, the more valuable the deposit.

In the graphite beds the chief associated mineral is quartz and in many places a white fibrous mineral, probably sillimanitte, is present to a considerable amount. Mica, garnet, and in the unweathered zone, pyrite, are very common accessory minerals.

Depths of Weathering.

The zone of weathering in the graphite beds varies considerable with the locality. In some places 25 to 30 feet would cover the depth of weathering, while in others it has reached to a probable depth of from 80 to 100 feet. In most places 40 to 60 feet is the common depth of weathering, and below this the rock becomes bluer in color, higher in pyrite, and much harder. It is not always true that the greater depths of weathered rocks are to be found on the higher rides. The open structure of the rock, the mineral content and topographic situation are all governing factors which must be taken into consideration.

At the present stage of the milling industry only the weathered or partly weathered rock is run through the mill, since it is more easily crushed and yields a larger flake on account of the less attrition attendant upon its reduction.

Taking the graphite ore from the open pits is a comparatively simple and inexpensive process. Occasional shots are necessary to loosen the rocks, but pick and shovel, quarry bar and sledge are largely employed in getting out the rock and reducing it to sizes suitable for the crushers. It is of great advantage to open the quarry in such places as to avoid excessive stripping and the condition of an overhanging wall. Beds which are vertical or nearly so or which have a dip direction with the slope of the hill offer the most nearly ideal conditions. There is a tendency on the part of the beginner to underestimate the amount of quarry working space necessary to supply ore for a good sized mill, and one should make plans to have sufficient openings to supply the needed ore before going forward with the erection of a large tonnage mill.

MAKE SURE OF ORE SUPPLY.

As is the case in all lines of business in which large profits are being made, speculation is present and parties intending to put up plants for the milling of graphite ore, should first make sure of their ore supply. While locally the beds have considerable continuity, it is never safe to bank on this.

An important fact which it seems necessary to mention is that the character of the ore on a property cannot be told from the analysis of one piece of rock, nor indeed several. The sample to be tested should be representative of the entire width of the contemplated workable seam.

There are several methods employed in the Alabama field at the present time for the reduction of the ore and its separation. Most of the processes are comparatively new and have not yet been perfected. In the reduction of the ore the processes which bring about a gradual reduction in the size of the ore and give the least rubbing of the ore, give the best results by yielding a higher percentage of No. 1 flake and less dust. A gradual reduction by the use of several sets of rolls is coming more into favor.

At the present time most of the mills are employing the wet process of separation by flotation and all but one of these are using water without oil. The dry method of separation has proven successful for certain parts of the field and will doubtless he more used as an auxiliary in the mills using the wet process as time goes on. The electrostatic process for the separation of mica and graphite has also proven locally successful, and with certain changes in the character of the machine to adapt it to local differences of ore could probably be used successfully. It is difficult to tell which of the various processes gives the best results. There is a wide difference at the present time among those using approximately the same method of separation in the percentages of graphite recovered. The efficiency of the washers, for instance, depends on various factors; the dimensions, the rate of flow of the water, the evenness or rate of feed, the condition of the ore, the angle at which the ore hits the water, the character of the ripples, etc. The best results are obtained by those who have most scientifically constructed washers, and who are able to adapt the washer or other separating machinery to the local conditions.

IRON ORE.

EUGENE A. SMITH.

IRON ores of Alabama in the order of their economic importance are (1) red ore or hematite; (2) the brown ore or limonite; (3) the gray ore. The black band and clay iron stone have been noticed as occurring in a number of places, but only the red ore and the brown ore have been mined on any large scale.

Practically all the ore mined in Alabama is smelted in the State, the shipments out of the State being about equal to those received from other States.

The tables given below will show the rank of Alabama among the States of the Union both in the production of iron ore and in pig iron.

RED ORE OR HEMATITE.

All the ore of this quality mined in Alabama occurs in the Clinton or Red Mountain formation. The Red Mountain ridges occur on each side of the anticlinal valleys which separate the coal fields. In places the red ore ridges are lacking on one side, usually the western, of the valleys, being cut out by faults, while on the other hand the ridge may be duplicated on one side of the valley by the same faults.

In most of the valley occurrences the moderate dips of the ore bed are on the eastern side and there are also practically all of the ore mines. Murphree's Valley makes an exception to this, the moderate dips and the iron mines being on the western side. The iron ore occurs mainly in the central part of the formation in seams or beds one to five in number, which vary in thickness from a few inches to thirty feet.

While the ore seams are very persistent along the outcrop which in Alabama must be as much as 50 miles, yet they vary greatly from place to place, being either too thin or too lean for profitable working in the greater part of this distance.

The most important development of the Clinton ore in this State and in the world is along the 15 or 16 miles stretch of the east Red Mountain between Birmingham and Bessemer, and there is a practiacally continuous series of mines and strippings for this entire distance. Much mining of this ore has also been done near Gate City, Village Springs, Attalla, Gadsden, Round Mountain, Gaylesville, Ft. Payne, Valley Head, etc.

The completion in October, 1912, of a diamond drill boring in Shades Valley, within a mile of the base of Shades Mountain, gives a definite answer to the speculations concerning the occurrence of red ore under Shades Valley. This boring shows that there is no falling off in the thickness and quality of the ore with distance from the outcrop, and that the depth of the ore below the surface at a distance of more than 2½ miles from the outcrop on Red Mountain is not too great for shaft mining.

The elevation of the surface at the drilling is 595 feet. The top of the ore was reached at a depth of 1,902 feet and a section of the seam in descending order is:

Ore (self-fluxing)	9 ft. 6 in.
Shale	4 in.
Ore (Siliceous)	9 ft. 6 in.

An analysis of an average sample of the drill core of the upper bench, made by David Hancock, shows as follows:

	Per Cent.
Metallic iron	39.51
Silica	9.94
Alumina	3.34
Calcium Carbonate	24.20
Magnesium carbonate	.78
Metallic manganese	.20
Phosphorus	.32

The importance of this demonstration of a vast increase in the amount of red ore available immediately or in the near future, cannot well be overestimated.

In 1913 the Gulf States Steel Company acquired about 1,500 acres of land upon which the drill hole above mentioned was located. They have since sunk a double track slope to the ore. In time this is likely to be the largest producing mine in the State.

Another drill hole was put down in Shades Valley in 1913, in Section 19, T. 19, R. 3 W., but the records are not available for publication at the present time.

The hematite production in Alabama for 1915 was 4,374,309 long tons, as against 3,902,567 tons in 1914, an increase of 471,742 tons or 12.1 per cent.

This 1915 production of hematite is 82.4 per cent of the total iron ore production of the State, and 8.4 per cent of the total iron ore production of the United States.

The average price of hematite in Alabama in 1914 was $1.21: in 1915, $1.25.

BROWN ORE OR LIMONITE.

This ore, the second of importance in the State and third in the United States, furnished only 1.7 per cent of the total iron ore production of the United States and 17.6 per cent of the iron ore production of the State in 1915. The entire limonite production of the United States in 1915 was 1,488,709 long tons of which Alabama contributed 935,045 tons or 62.8 per cent, and the State holds accordingly the first rank in this industry.

In the early days of iron making and up to the year 1876 this was the only ore used in the catalan forges, bloomaries, and charcoal furnaces of the State. It was then demonstrated that good iron could be made at low cost from the red ores, with coke for the fuel.

In general the limonites are considered the best of the ores of Alabama and they command the highest prices and command a ready sale.

The usual mode of occurrence is in irregular masses of concretionary origin in the residual clays resulting from the decomposition of limestones, and as a consequence the mining is uncertain and expensive. Limonite also occurs in regularly stratified seams or beds, and then it is the result of the alteration of pyrites or of carbonate ores. Practically all of the brown ore actually mined is that occurring in the residual clays above mentioned. Most of the ore before going to the furnace is washed and screened, and this manipulation, together with the cost of mining, makes it the most expensive of the iron ores, and it is therefore seldom used alone, but is usually mixed with the red ore in proportions determined by the quality of the iron desired. It is used alone in the charcoal furnaces and also in the coke furnaces when a particularly tough pig iron is wanted.

The limonite deposits are very numerous and are distributed over a broad expanse of country and in many places are known to be very extensive. In some of the deposits the ore is in nearly solid mass, in others it is much scattered, and in consequence the amount of foreign material necessary to be moved for every ton of ore produced, varies very much, not only in the different ore banks, but also in the different parts of the same bank.

The deposits occur in nearly all the geological formations of the State, but in most of these the ore is either insufficient in quantity or not pure enough to be of much commercial value. The most important of the deposits, in point of extent and value, occur overlying the following formations, viz., the Knox Dolomite and the Weisner Quartzite, the Lauderdale Chert of the Lower Carboniferous, and the Lafayette. Some extensive beds of ore of inferior quality generally occur also in the Tuscaloosa formation of the Cretaceous, and in the upper part of the Lower Carboniferous and in the Metamorphic rocks.

The limonite or brown ore production of Alabama in 1915 was 935,045 long tons as against 936,392 tons in 1914, a decrease of 1,347 tons, or .14 per cent.

The average price per long ton of brown ore marketed in Alabama in 1915 was $1.68, as against $1.49 in 1914.

DETAILS OF IRON ORE PRODUCTION IN ALABAMA, 1915.

The following tables show details concerning the production of iron ore in the State, together with the rank of the State in mined and marketed iron ore in 1914 and 1915:

Iron ore mined in Alabama, 1914-1915, by varieties, with percentage of increase in 1915 in long tons.

Year	Hematite	Brown ore	Total quantity	Percentage of total U. S. produc'n
1914	3,902,567	936,392	4,838,959	11.68
1915	4,374,309	935,045	5,309,354	9.74
Increase or decrease	+ 471,742	— 1,347	+ 470,395	———
Percentage	+ 12.1	— 0.1	+ 9.4	———

Iron ore marketed in Alabama in 1914 and 1915, by varieties, in long tons.

Year	Hematite	Brown ore	Total quantity	Total value
1914	3,589,809	925,117	4,514,926	$5,727,619
1915	4,199,910	935,045	5,134,955	6,798,266
Increase in 1915	610,101	9,928	620,029	1,070,647
Percentage of increase	16.9	1.1	13.7	18.7

Average price per gross ton of iron ore shipped from mines in Alabama and the United States, 1914-1915.

	Hematite		Brown Ore	
	1914	1915	1914	1915
Alabama	$1.21	$1.25	$1.49	$1.68
United States	1.79	1.80	1.72	1.80

Rank of the first five states in mined and marketed production of iron ore in 1914 and 1915.

1914

Rank	State	Mined		Marketed			
		Quantity (long tons)	Percentage of total production	Quantity (long tons)	Percentage of total production	Value	Percentage of total value
1	Minnesota	21,946,901	52.96	23,298,547	58.66	$40,628,771	56.50
2	Michigan	10,796,200	26.05	8,533,280	21.49	18,722,358	26.04
3	Alabama	4,838,959	11.68	4,514,926	11.37	5,727,619	7.97
4	Wisconsin	886,512	2.13	591,595	1.49	1,178,610	1.64
5	New York	785,377	1.90	640,252	1.61	1,992,892	2.77

1915

Rank	State	Quantity (long tons)	Percentage of total production	Quantity (long tons)	Percentage of total production	Value	Percentage of total value
1	Minnesota	33,464,660	60.27	32,545,236	58.68	$57,742,648	57.01
2	Michigan	12,514,516	22.54	13,664,437	24.63	28,218,627	27.86
3	Alabama	5,309,354	9.74	5,314,955	9.76	6,798,266	6.71
4	Wisconsin	1,095,388	1.97	1,125,269	2.03	2,188,012	2.16
5	New York	998,345	1.79	931,745	1.68	2,797,270	2.76

PRINCIPAL IRON ORE MINES.

In 1914 and 1915 there were three hundred and forty iron ore mines active in the United States as compared with 411 in 1913, and 184 mines produced more than 50,000 long tons of ore each in 1915, as compared with 164 mines in 1914.

The Red Mountain group of red hematite mines in the Birmingham district, Alabama, led in 1915, with an output of 2,138,015 long tons of ore, this quantity is nearly 130,000 tons more than the output of this group in 1914. Six of the seven mines producing more than 1,000,000 tons each in 1915 are in Minnesota.

Iron ore mines of Alabama that produced more than 50,000 long tons each in 1915.

Rank.	Name of Mine	Nearest Town	Variety of Ore	Quantity
1	Red Mountain Group	Bessemer	Hematite	2,138,015
2	Woodward, 1, 2 and 3	Lipscomb	Hematite	880,737
3	Raimund No. 1	Bessemer	Hematite	221,955
4	Songo	Songo	Hematite	210,369
5	Greeley	Greeley	Brown Ore	157,914
6	Steinman	Steinman	Hematite	125,133
7	Raimund, No. 2	Bessemer	Hematite	118,911
8	Attalla	Attalla	Hematite	88,712
9	Friedman	Woodstock	Brown Ore	81,684
10	Ironaton	Ironaton	Brown Ore	77,870
11	Houston	Rickey	Brown Ore	77,453
12	Raimund, No. 3	Bessemer	Hematite	74,568
13	Tannehill	Goethite	Brown Ore	70,991
14	Docray	Docray	Brown Ore	56,729
15	Champion	Oneonta	Brown Ore	55,427

*Includes the product of three mines, producing over 50,000 tons each, operated by two companies which do not permit the publication of individual statistics.

Total 15 mines	4,436,468
Unspecified (3 mines)	753,548
Tonnage from 18 mines producing over 50,000 tons	5,190,011
Tonnage from 12 mines producing less than 50,000 tons each	119,343
Grand total of Alabama production	5,309,354

PIG IRON.

Quantity and value of pig iron (exclusive of ferro-alloys) marketed in the United States in 1914 and 1915 (first five states), with increase and percentage of increase in 1915, in long tons.

	1914		1915		Increase in 1915		Percentage of increase in 1915	
	Quantity	Value	Quantity	Value	Quantity	Value	Quantity	Value
1. Pennsylvania	9,267,197	$127,686,331	12,779,974	$174,926,891	3,512,777	$ 47,240,560	37.9	36.9
2. Ohio	5,226,925	70,331,114	6,995,000	90,549,626	1,768,075	20,218,512	33.8	28.7
3. Illinois	1,793,714	24,382,458	2,455,894	34,207,901	662,180	9,825,443	36.8	40.3
4. Alabama	1,661,420	17,481,828	2,320,255	23,757,124	658,835	6,275,296	39.6	35.9
5. New York	1,357,575	19,353,309	2,010,076	28,178,466	652,501	8,825,157	48.1	45.6

Average price per gross ton of pig iron in Alabama and the United States, 1911-1915.

	1911	1912	1913	1914	1915
Alabama	$10.75	$10.75	$12.08	$10.52	$10.24
United States	14.07	13.98	15.08	13.42	13.21

LIME.

EUGENE A. SMITH.

DURING the year 1915 there was an increase in the production of lime in Alabama, as compared with the production of the preceding year. The total product of 14 operators in 1915 was 60,332 short tons, an increase from the 1914 production of 13,366 short tons or 28.4 per cent. The value of the product was $250,227, an increase of $50,413, or 25.2 per cent.

As heretofore, the most important use of the lime produced was for building purposes. 21.8 per cent of the State's total production is definitely so accredited in the returns, which added to the 10.4 per cent in the form of hydrated lime, produced by 3 operators, give 32.2 per cent definitely assigned to building purposes. Of the 66.4 per cent sold to dealers, uses not specified, a large proportion undoubtedly goes for building purposes, so that probably more than 50 per cent, possibly 75 per cent of the product is thus used. Other chief uses for lime are in chemical works, paper mills, soap factories, manufactories of sand-lime brick, slag cement, etc.

Shelby County, as heretofore, was the largest producer in 1915, having produced 41,883 tons, or about 70 per cent of the total. The other producers in the order of their rank, were Blount, Etowah, Jackson, and Jefferson.

The following tables present some additional data on the lime production in Alabama in 1914 and 1915:

Production of lime, 1914 and 1915.

	Number of operators	Quantity (short tons)	Rank of state by quantity	Value	Rank of state by value	Average price per ton	Percentage of total U. S. value
1914	12	46,966	17	$199,814	18	$4.25	1.5
1915	14	60,332	16	250,227	17	4.15	1.4
Increase	2	13,366	....	50,413	....	....	....
Percentage	17	28.4	....	25.2	....	....	....

Number of lime kilns in Alabama using various kinds of fuel in 1914 and 1915.

Year	Coal	Producer gas	Wood	Coal and Wood	Total number of kilns
1914	8	8	10	9	35
1915	*6	8	8	20	42

*5 coal and 1 coke.

Those interested in the subject of lime are referred to an article on Lime by Ralph W. Stone of the U. S. Geological Survey, and on the Source, Manufacture, and Use of Lime, by E. F. Burchard and Warren E. Emby of the U. S. Geological Survey, in Vol. II of the Mineral Resources of the United States for 1913, and to the section on Lime by G. F. Loughlin, in Mineral Resources of the United States for 1915.

MICA.

MICA mines were opened in Alabama during the early days of mica mining in the Southern States. Prospects have been tested at various subsequent times, and considerable mining has been carried on at intervals during the last 20 years. The mines are located in Randolph, Cleburne, Clay, and Tallapoosa counties, and there are prospects in Lee, Coosa, Chilton and other counties.

In 1915 there were four mines producing mica. The output was 8,400 pounds of sheet mica valued at $5,545, also several hundred dollars worth of scrap mica.

MINERAL WATERS.

R. B. DOLE.

RETURNS from Alabama indicate that the mineral-water trade in 1915 was little more than half that in 1914. The sales amounted to 86,499 gallons, and the value of the output was $8,912, the average price per gallon, 10 cents, remaining the same. The decrease was chiefly in sales of table waters. Fourteen springs reported sales; four springs regarding which no reports have been received for two years have necessarily been considered idle. Four mineral-water bathing establishments and five resorts accommodating about 650 guests were maintained. A small amount of mineral water also was used in the manufacture of soft drinks.

The following 14 springs reported sales:

Bailey Springs, Florence, Lauderdale County.
Bladon Springs, Bladon Springs, Choctaw County.
Bromberg Gulf Coast Lithia Spring, Bayou Labatre, Mobile County.
Cooks Springs, Cooks Springs, St. Clair County.

Dixie Spring, Dixie Spring, Walker County.
Healing Springs, Healing Springs, Washington County.
Ingram Lithia Well, near Ohatchee, Calhoun County.
Livingston Mineral Spring, Livingston, Sumter County.
Luverne Mineral Spring. Luverne, Crenshaw County.
McCary Mineral Well, near Birmingham, Jefferson County.
Matchless Mineral Wells, east of Greenville, Butler County.
Purity Spring, Spring Hill, Mobile County.
Shocco Spring, Talladega, Talladega County.
White Sulphur Wells, near Jackson, Clarke County.

The following table shows the relative productions and their respective values of mineral and table water in 1914 and 1915:

Production and value of mineral and table waters sold in 1914 and 1915.

	Number of springs reporting	Quantity sold (gallons)	Average retail price	Total value of mineral waters	Percentage of total U. S. value
1914	15	169,279	.10	$17,125	0.35
1915	14	86,499	.10	8,912	0.17
Decrease	1	82,780	....	8,213	....
Percentage	6.6	48.3	....	47.9	....

The quantity of water used in the manufacture of "soft drinks" in 1914 was 86,500 gallons; in 1915, 2,300 gallons.

NATURAL GAS.

JOHN D. NORTHROP.

THE natural-gas industry in Alabama is of little consequence. In 1915 natural gas in sufficient quantities to supply the needs of 291 consumers in the town of Fayette was obtained from three wells in the Fayette gas field, Fayette County, and enough for the needs of 150 consumers in the town of Jasper was obtained from two wells in Walker County. In the Fayette field the wells range in depth from 1,400 to 1,440 feet. In the Walker County field gas is obtained at a depth of 1,800 feet. One gas well was drilled in the Fayette field in 1915.

Because of the small number of producers, the statistics of production and consumption of natural gas in Alabama cannot be given, without revealing confidental data furnished by individual companies.

OCHER.

JAMES M. HILL.

OCHER is a hydrated ferric oxide permeating a clay base. It has a specific gravity of about 3.5 and a decidedly golden-yellow color. As viewed under the microscope and with considerable enlargement the particles composing ocher appear flocculent and uniform. Good grades should contain 20 per cent or more of iron oxide, though there is a wide variation in the iron content of the material sold as ocher. Ferruginous shale is often ground and the product marketed as ocher, but unless the material is actually an ocher, as defined above, such product is classed under slate and shale in this chapter.

In 1913 ocher was produced in Georgia, Pennsylvania, Virginia, Alabama, California, Iowa, and Vermont, the States being named in the order of their producing importance. In 1913 Alabama re-entered the class of ocher producers, a new mine being opened in Clarke County.*

Since the beginning of the European war domestic ochers have been more used than heretofore. It is the general opinion among the users of this pigment that the domestic ocher does not compare with the French ocher in tone, color, or strength. It seems to be the case, as in many American industries, that the producers will not prepare their materials with the care used by the foreign manufacturers. It is the belief of the writer that some domestic ochers could be made equal to the French ochers in every respect if American producers would give more attention to the details of cleaning and floating. It has been said of American ochers† that, "by skillful handling, a thoroughly satisfactory color can be obtained. This is done by tinting the ocher with American chrome yellow until the correct shade is obtained."

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*This mine was the only producer of ocher in 1915, but there are many promising deposits of ocher in Alabama, especially in the area of the Tuscaloosa formation of the Cretaceous, as well as in other parts of the Coastal Plain southward nearly to the Gulf.—E. A. S.

PETROLEUM.

BY EUGENE A. SMITH.

OCCURRENCES of tar springs, bituminous limestones, and bituminous sandstones in the Tennessee Valley, have been reported as far back as the time of Prof. Tuomey, the first State Geologist, and many notices of these things have appeared in subsequent reports of the Geological Survey, especially the Report on the Tennessee Valley Region by Mr. Henry McCalley. In this report will also be found somewhat full accounts of the Goyer wells, put down in the Moulton Valley some time in the early part of '91. From these wells small quantities of oil were obtained and the report above named gives some analyses of the oil. In the same report are accounts of deep wells near Hartselle, Newmarket and Huntsville, from some of which small amounts of oil were obtained. Later borings in the mineral district of North Alabama have obtained some small quantities of oil; as at Bryan station in Jefferson County, Jasper in Walker and Cordova, also in Walker. The last named boring struck a small pocket of oil at the depth of 835 or 840 feet during the latter part of December, 1916. Other borings further north at Hamilton in Marion County, and Atwood in Franklin County, have also yielded oil-saturated sands and small quantities of oil. Some of the drillings also in the Fayette County gas field have passed through oil sands, according to report.

In South Alabama, around the Hatchetigbee anticlinal in Choctaw, Washington and Clark counties, there have been several deep borings after oil, but none in any commercial quantity has yet been brought in.

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†Paint, Oil, and Drug Rev., vol. 58, p. 4, Sept. 16, 1914.

The striking of the oil pocket at Cordova in December, 1916, which yielded oil in quantity measurable by the barrel, has greatly stimulated the search for oil in Alabama, and companies are now, (March, 1917), quite active in nearly all parts of the State. There seems, therefore, to be no reason to doubt that in the next 12 months we shall be able to class Alabama as one of the oil-producing states.

SAND AND GRAVEL.

THE total production of sand and gravel in the State in 1915 was 924,701 short tons, valued at $242,336, as compared with 831,430 tons, valued at $262,219 in 1914, an increase in quantity of 93,271 tons or 11.2 per cent, and a decrease in value of $19,883 or 7.6 per cent.

There was an increase in the quantity of sand of 73,506 short tons or 24.2 per cent, and in value of $2,138 or 1.7 per cent.

In the quantity of gravel there was an increase of 3.7 per cent, and a decrease in the value of 15.9 per cent.

Over 42 per cent of the sand was used for building purposes.

The following tables give a comparison of the production of sand and gravel in 1914 and 1915, and the production, value and disposition of the sand in these two years.

Production in short tons of sand and gravel in 1914 and 1915.

	Sand		Gravel		Total*		Percentage of total U. S. value
	Quantity	Value	Quantity	Value	Quantity	Value	
1914	303,539	$123,526	527,891	$138,693	831,430	$262,219	1.10
1915	377,045	125,664	547,656	116,672	924,701	242,336	1.05
Increase or decrease	+73,506	+ 2,138	+19,765	—22,021	+93,271	—19,883	....
Percentage	+ 24.2	+ 1.7	+ 3.7	— 15.9	+ 11.2	— 7.6	....

*Chert has been added to these totals.

Production (in short tons), value and kinds of sand in 1914 and 1915.

	Moulding Sand		Building Sand		Grinding and Polishing Sand		Fire Sand		Paving Sand		Engine Sand		Other Sand		Total	
	Quantity	Value	Quantity	Value	Quantity	Value	Quantity	Value	Quantity	Value	Quantity	Value	Quantity	Value	Quantity	Value
1914	92,551	$43,702	152,800	$51,792	8,052	$4,104	22,135	$6,450	5,849	$4,538	12,040	$3,127	10,112	$9,813	303,539	$123,526
1915	169,663	59,862	157,581	51,788	*	*	*	*	*	*	6,942	1,779	7,294	2,180	†377,045	125,664
Increase+ or Decrease—	+77,112	+16,160	+4,781	— 4	....	....	....	....	....	....	—5,098	—1,348	—2,818	—7,633	+ 73,506	+ 2,138
Percentage	83.4	37.0	3.6	.001	....	....	....	....	....	....	42.3	43.1	27.9	77.7	24.2	1.7

*Concealed because of less than three producers.
†Including "Concealed Totals."

SILICA (QUARTZ).

By Frank J. Katz.

Uses.

SILICA (quartz) as discussed in this chapter is used for many purposes, principally in the manufacture of pottery, paints, and scouring soaps, as a wood filler, as a polisher, and in metallurgical and chemical processes. In the pottery industry, where it is generally called flint, silica is used in the body of the ware to diminish shrinkage and is also used in glazes. Silica for use in pottery should contain less than 0.5 per cent of iron-bearing minerals. Manufacturers of paint use considerable quantities of very finely ground silica, which forms as much as one-third of the total pigment in some paints. For this purpose finely ground crystalline material is superior to fine sand in its natural state because of the angularity of the grains, which makes them adhere more firmly to the article painted and after wear affords a good surface for repainting. The same angularity makes artificially comminuted crystalline quartz superior to natural sand for use in wood fillers. For soaps and polishing powders ground material is preferred to natural sand on account of its whiteness and angularity. For all these purposes large quantities of pure quartz sand and standstone are finely ground and yield a product fully equal to that obtained by grinding massive crystalline quartz.

The material known commercially in the United States as tripoli, which is the siliceous residue of decomposed limestones, also yields an excellent grade of pulverized silica, which is used for the same purpose as silica powder obtained from massive crystalline quartz and from sands and sandstones. Diatomaceous (infusorial) earth is also used to make polishing powder that is employed for similar uses to those for which quartz, sand, and tripoli powders are employed, but diatomaceous earth has somewhat different properties and most of it finds different application.

Quartz crushed and graded to various sizes is used in making sandpaper and sand belts, as a scouring agent, for "frosting" glass with sand-blast apparatus, and for other purposes. Blocks of massive quartz and quartzite are used in the chemical industry as a filler for acid towers and as a flux in copper smelting. Ground quartz is also used in filters and in tooth powders and by dentists as a detergent.

Sand and crystalline quartz have been used in making silicon and alloys of silicon with iron, copper, and other metals in the electric furnace. Quartz may be used in the electric furnace to make chemical apparatus, such as tubes, crucibles, and dishes.

PRODUCTION.

In Alabama one firm made an initial production of sandstone near Trussville, Jefferson County, from property acquired late in the year and reported that a mill for grinding would be put into operation.

STONE.

EUGENE A. SMITH.

ON ACCOUNT of the variety of uses to which stone is put, there is no regular unit of measurement, and the figures in this report represent the values of the different varieties.

PRODUCTION.

Alabama produces only three kinds of stone, viz., limestone, marble, and sandstone.

The total value of the production of stone in Alabama showed a decrease in 1915 of 45.5 per cent. The greater part of this decrease was in the limestone (rough building stone, crushed stone for road making, and concrete,) and for agricultural purposes. The standstone also showed a decrease. There was also a notable decrease in the value of the marble produced. Eact figures for marble, however, cannot be given except for the year 1914, since before 1914 there were less than three producers.

The following table gives some additional details concerning the total stone production:

Total value of stone (limestone, sandstone and marble) produced in Alabama in 1914 and 1915, percentage of total U. S. value, rank of state and number of plants.

Year	Total Value	Percentage of total U. S. value	Number of Plants	Rank of State
1914	$1,319,753	1.71	38	22
1915	719,452	.96	25	28
Decrease in 1915	600,301			
Percentage	45.5			

LIMESTONE.

The most important use of the limestone produced in Alabama in 1915 as in 1914 was for furnace flux, while crushed stone for road-making and concrete follow next in importance. A very decided decrease in the amount of ground limestone for agricultural purposes, is to be noted.

The limestone burned into lime or used in the manufacture of Portland cement is not taken into account here, but is included in the value of each of the finished products in whose manufacture it was used.

As thus limited the total value of the limestone produced in 1915 was $426,266, as compared with $787,214 in 1914, a decrease of $360,948, or 45.9 per cent.

The value of the limestone produced in 1914 and 1915 classified according to the uses of the stone, are given in the following table:

Value of limestone (not including marble) produced in 1914 and 1915, according to uses.

Uses	1914	1915	Increase or Decrease	Percentage
Rough building	$20,992	$6,912	— $14,080	— 67.1
Dressed building	20,558	15,487	— 5,071	— 24.7
Rubble		800		
Riprap	3,882	18,379	+ 14,497	+ 373.4
Crushed Stone:				
Road making	75,528	42,116	— 33,412	— 44.2
Railroad ballast	1,076	554	— 522	— 48.5
Concrete	287,119	45,443	— 241,676	— 84.2
Flux	360,691	289,167	— 71,524	— 19.8
Agricultural	17,365	7,386	— 9,979	— 57.5
Other		22		
Total	$787,211	$426,266	—$360,948	— 45.9

LIMESTONE FOR BUILDING PURPOSES.

The preparation of cut stone for building purposes in Alabama, while on the increase, is not yet what it should be. Practically all of this material comes from the quarries in the subcarboniferous limestone of the Tennessee Valley, the most important quarries being at Rockwood in Franklin County, operated by Foster and Cheighton Co., of Nashville. This stone is quite similar in appearance, composition, and other qualities to the Indiana stone, and so far as experience in the use of the stone from the two localities in the buildings of the University of Alabama goes, the Alabama stone holds its own under influence of the weather better than does the Indiana stone. Stone steps, door sills, and window sills, buttress caps, etc., of the Alabama stone put in place in 1885 show practically no deterioration in color and wear under foot, and in crumbling and roughening under the influence of the weather, which cannot be said of some portions of the Indiana stone used in buildings erected in 1909-10. The Rockwood quarries have most modern and approved methods of machinery for sawing the stone and handling it in transit to the mills and elsewhere. The stone is of massive formation, of great thickness and extent. Blocks weighing as much as 25 tons, without crack or flaw, are not infrequently quarried, the size of the blocks being practically limited only by the capacity of the hoisting machinery.

The Oolitic variety is most extensively used for building and monumental work. It is of light gray color, uniform grain, and homogeneous texture. It possesses a quality of cheapness, it can be cut to any design required, and is at the same time strong and durable.

With the installing of adequate machinery at the quarry for doing the finished work, there should never be any longer any reason for going outside of the State for this quality of stone. Already the material has been very extensively used in public buildings in Mississippi, Tennessee, as well as in Alabama. The only reason why it was not used in the recently erected buildings at the University of Alabama was that at the time these building contracts were let, the quarries furnished only the rough sawn stone and there was not in Alabama any establishment adequately equipped for the dressing of the stone in the quantity needed.

The above statements are confirmed by a report on the comparative tests made on the Rockwood stone, and those from Bedford, Ind., and Bowling Green, Ky., by Prof. Robert H. McNeilly, in the Engineering Laboratory of Vanderbilt University.

From this report I give the following extracts:

"General Characteristics.—The Rockwood limestone is an almost pure oolitic limestone with frequent small crystals of calcite distributed throughout its mass. It resembles closely the Bedford stone in appearance, except that it has a slightly more open texture. The Bowling Green stone is finer in grain, softer and more easily pulverized than either the Bedford or Rockwood stones, and contains an appreciable amount of petroleum, which lends somewhat to the ease with which it is worked. In all three stones the texture is exceptionally uniform, as it is almost impossible to detect the bedding planes by eye; however in this respect the Bowling Green stone is most marked, and it is frequently necessary to test by hammer to detect which is the bed plane. Rockwood stone is lighter in color than either the Bedford or Bowling Green stones.

"Chemical Analysis.—The following is an analysis of the Rockwood stone made at my request by Dr. Paul C. Bowers, Chief Chemist of the Tennessee Geological Department:

	Rockwood Stone.
Moisture and loss on heating to 175° C.	0.07
Insoluble siliceous residue (SiO_2, etc.)	0.49
Oxide of Iron and Alumina (Fe_2O_3 & Al_2O_3)	0.30
Carbonate of Lime ($CaCO_3$)	98.23
Carbonate of Magnesia ($MgCO_3$)	0.97
Total	100.06

"Physical Tests.—Comparative physical tests of the three samples of stone were made as follows:

Loss in weight on drying,
Cross bending tests,
Compression tests,
Absorption tests,
Per cent of water absorbed,
Specific gravity in bulk, and of pulverized stone,
Density,
Abrasion tests.

The results of these physical tests are summarized in the Conclusions below quoted.

"CONCLUSIONS.—The above tests were made as nearly as possible, under identical conditions, and barring the accidental characteristics of the samples, which were selected at random, these results are believed to represent truly the comparative characteristics of each of the stones under consideration.

"The Rockwood Stone shows itself to be a superior building stone to others in every respect except density—but even here, since its absorption of water is the lowest of the three, it should prove more durable, while the smaller weight per cubic foot can be placed more cheaply on account of freight charges.

"As compared with the Bowling Green stone, the Rockwood shows a decidedly higher strength, and characteristics which indicate a greater durability. The Bowling Green stone, however, is undoubtedly more easily worked than either of the other two stones, due to its being softer and also to the presence of oil. This oil has the bad effect of staining the stone itself and the contiguous masonry for several years after it is placed, while the very ease with which the stone can be worked makes the Bowling Green very inferior where used for door sills and steps. This is shown well by the Abrasion Test which shows the Rockwood stone in its best light, as a very superior material for steps, door sills, and other places subject to wear.

"From my examination of these three stones, I believe no builder would make a mistake in using any one of the three, for they are all unquestionably very superior building stones. While each stone may have advantages over the other for some specially desired characteristics, as a building stone for general purposes, each is highly satisfactory.

Respectfully submitted,
ROBERT H. MCNEILLEY,
Assistant Professor of Civil
Engineering, Vanderbilt University."

MARBLE.

The marble of Alabama is of two kinds, crystalline, or true marble, and non-crystalline.

The crystalline or statutary marble occurs mainly in a narrow valley along the western border of the metamorphic area, extending from Marble Valley in Coosa County, through Talladega into Calhoun. The length of the marble belt through

Coosa and Talladega counties is about 50 miles. The width of the valley carrying the marble as a rule is from one quarter to one-half mile, widening in places to a mile and a quarter, for example in the neighborhood of Sylacauga.

The quarries longest known are Gantt's and Herd's near Sylacauga, Nix's near Sycamore, Bowie's near Rendalia, and Taylor's and McKenzie's near Taylor's Mill, east of Talladega. From all of these marble was quarried before the civil war.

During 1915 two companies reported production of marble in Alabama, viz., the Alabama Marble Company at Gantt's Quarry and the Moretti-Harrah Company, whose quarry adjoins that of the Alabama Marble Company at Gantt's. The other quarries mentioned are in Talladega county, near Sylacauga.

The plant of the Alabama Marble Company at Gantt's Quarry which was completely destroyed by fire in December, 1910, has been rebuilt and equipped with all the machinery needed for the working up of any kind of finished product.

I think it is fairly safe to say that on the whole the marble from this quarry and immediate vicinity is of the highest grade of commercial white marble now on the market and obtainable in large quantity. There are small quantities of marble produced both in Italy and Vermont that are somewhat freer from coloring matter than the best grades that can be produced in Alabama in any quantity. But on the other hand, the poorest grades in Alabama greatly surpass the poorest grades produced elsewhere, so that the average of the Alabama deposit is probably somewhat higher than that of any other so far developed, not excluding even the marble from the Carara district in Italy. The marble from this State (Gantt's Quarry) has now a well established reputation and has been used in more than 200 important buildings throughout the United States.

It can be seen in the galleries of the National Museum in Washington.

The Moretti-Harrah Company furnishes the marble in blocks for monumental and rough interior purposes.

A beautiful quality of variegated limestone or marble—red, pink and white—belonging probably to the Cambrian formation, occurs in Shelby County, a mile or two south of Shelby Springs station on the L. & N. railroad, and extending thence southwest for a mile or two. Nothing but prospecting work has been done on this marble. The Trenton limestone in the Appalachian valleys, particularly Jones Valley below Bessemer, contains marble similar to that quarried in the vicinity of Knoxville, Tenn. Also as to Pratt's Ferry on the Cahaba River in Bibb County a quarry was for many years worked in this formation and turned out a very beautiful quality of marble varying in color from gray through pink, red and brown shades.

A black marble which is exceedingly promising, has been reported and some development work done near Anniston, and at Piedmont, Calhoun County, and some very handsome specimens of cave onyx have been obtained from near Kymulga in Talladega County.

In the Coastal Plain the St. Stephen limestone of the Tertiary holds ledges of hard, almost crystalline rock capable of taking good polish. The colors vary from nearly white, through shades of yellowish into red, and it would make a handsome decorative marble, especially for inside work.

Other limestone formations, such as the Subcarboniferous and the Knox Dolomite, could in places be drawn upon for marble.

SANDSTONE.

As may be seen in the tables below, the production of sandstone in 1915 shows a decrease in total value of $131,341, or 81.2 per cent as compared with 1914.

Value of sandstone production in Alabama, 1914 and 1915, according to uses.

Use	1914	1915	Increase or Decrease	Percentage
Rough building	$57,079	$150	— $56,929	— 99.7
Ganister	2,300	4,500	+ 2,200	+ 95.7
Rubble	1,558	13,327	+ 11,269	+ 755.4
Riprap	15,694	12,455	— 3,239	— 20.7
Crushed stone—concrete	85,142	....	....	....
Total	$161,773	$30,432	—$131,341	— 81.2

Value of limestone and sandstone production in Alabama, 1911-1915.

Kind	1911	1912	1913	1914	1915
Limestone	$571,798	$531,085	$812,664	$787,214	$426,266
Sandstone	73,195	27,596	151,111	161,773	30,432

SUMMARY.

BECAUSE of the difference in the units of measurement employed in the various branches of the mineral industry, a summation of the production of the year can include only the values of the products. It is also to be noted that a simple summation of all the values of the minerals or mineral products listed in this pamphlet would give a value much in excess of the true value, since it many cases, as for instance, coal and coke, and iron ore and pig iron and steel, the second product is directly a product of the first, and the value of the first is included in that of the second. To give the values of both as a part of the total would be to repeat, in a measure, at least a partial value of the first or raw product, and would give an erroneous result.

As the Survey has not, however, the figures upon which to base an estimate as to the percentage of each product which was used in the manufacture of some other product, the summation of the mineral production of the State, as given here, will be a simple summation of the values reached by the individual branches of the industry.

According to this rather unsatisfactory manner of summation, which does not include the value of the steel produced, the value of the 1915 raw materials and immediately derived products, was $61,760,086, as compared with $56,769,559 in 1914 an increase of $4,990,527 or 8.78 per cent.

This production may be classified as follows:

Raw Products	$29,457,407
Pig Iron	23,757,124
Coke	8,505,555
Total	$61,760,086

The more important minerals and products after coal, pig iron and coke, are iron ores, clay products, stone, cement, sand and gravel and lime, given in the order of their relative value.

Below is a tabular presentation of the value of the mineral products of Alabama, as estimated above for the years 1911, 1912, 1913, 1914, and 1915.

Year.	Value.
1911	$52,772,951
1912	60,141,793
1913	67,530,089
1914	56,769,559
1915	61,760,086

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GEOLOGICAL SURVEY OF ALABAMA

EUGENE ALLEN SMITH, *State Geologist*

BULLETIN NO. 20

STATISTICS OF THE MINERAL PRODUCTION OF ALABAMA FOR 1916

COMPILED FROM THE MINERAL RESOURCES OF THE
UNITED STATES

By
EUGENE A. SMITH

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PRESS
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MONTGOMERY
ALABAMA

LETTER OF TRANSMITTAL

UNIVERSITY, ALA., December 15, 1918.

HON. CHARLES HENDERSON,
Governor of Alabama,
Montgomery, Ala.

SIR:—I have the honor to transmit herewith the manuscript of a Report on the Mineral Production of Alabama for the year 1916 with the request that it be printed as Bulletin No. 20 of the Geological Survey of Alabama.

Very respectfully,
EUGENE A. SMITH,
State Geologist.

GEOLOGICAL CORPS.

Eugene Allen Smith, Ph. D.	State Geologist
William F. Prouty, Ph. D.	Chief Assistant
Robert S. Hodges	Chemist
Herbert H. Smith	Curator of Museum
Roland M. Harper, Ph. D.	Botanist
A. T. Donoho	Stenographer
Geo. N. Brewer	Field Assistant

RIVER GAGE HEIGHT OBSERVERS.

Conecuh River at Beck, Alabama.

S. T. Dillard........Andalusia, Ala.

In service from October 1, 1914, to September 30, 1915

A. W. Lambert........Route F, Andalusia, Ala.

From October 1, 1915, to January 31, 1918

C. E. Raley........Route C, Andalusia, Ala.

From February 1, 1918, to September 30, 1918

Coosa River at Riverside, Ala.

J. E. Whitehead........October 1, 1914, to April 30, 1918

When the station was discontinued

Tallapoosa River at Sturdevant, Ala.

C. J. Stowe........October 1, 1914, to December 31, 1915

A. L. Stowe........January 1, 1916, to September 30, 1918

Big Bear River near Red Bay, Ala.

Ed Bullen........October 1, 1914, to September 30, 1918

Observations are made every day by these observers of the gage readings at the several stations. From these records when extended through sufficient time, the calculation of available horse power to be obtained from the different streams is made.

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PREFACE

The statistics of all the minerals included in the following pages have been collected in coöperation with the United States Geological Survey, and have been compiled from advance chapters of the *Mineral Resources of the United States,* a publication of the Federal Survey.

The introductory and general matter in each of these articles has either been taken without change from the U. S. advance chapters or has been rearranged or condensed from these chapters, or entirely rewritten to suit it to our present purposes. In each case credit it given to the author.

INTRODUCTION

EUGENE ALLEN SMITH.

AN INSPECTION of the subjoined tables will show that there has been in 1916 an increase both in quantity and value of the mineral products of the State with the exception of gravel, bauxite and sandstone, and an increase in the quantity of mica but a decrease in the value.

Following the plan set out by Mr. E. W. Parker in 1913, and continued by the Alabama Survey, we pass in review the production in 1915 and 1916 of Alabama minerals, and their immediate derived products, taking them up somewhat in the order of their commercial importance.

Coal.—Alabama's production of coal in 1916 was 18,086,197 short tons, valued at $24,859,831, an increase of 21.1 per cent in the quantity and 30.4 per cent in value as compared with 1915. As in 1915, the value of coal products in Alabama in 1916 was approximately three-fifths of the total mineral output of the State.

Coke.—The coke production of Alabama increased from 3,071,811 short tons, valued at $8,545,555, in 1915, to 4,298,417 tons valued at $15,019,139 in 1916, an increase in the value of 75.51 per cent.

Iron Ore.—In 1916 there was an increase of 27.09 per cent in the total quantity of iron ore production in the State as compared with 1915. 29.44 per cent in the quantity of the hematite and 15.06 per cent in the quantity of the brown ore.

Pig Iron.—In the quantity of pig iron marketed in Alabama in 1916, there was an increase from 1915 of 352,243 gross tons, or 15 per cent and of $15,237,536, or 64 per cent in the value. The value of this iron ore production, and not the value of the pig iron, is used in making up the total value of the mineral products of the State.

The total value of the mineral production of Alabama, excluding the value of pig iron and coke, and including the value of the iron ores and the coal was in 1916 $40,973,430, compared with $29,489,279 in 1915, of which, as already stated approximately three-fifths is represented by the products of the coal mines. More than one-fourth of the total value was contributed by the iron mines. The increase in 1916 from 1914 was $5,793,788, or 30.4 per cent.

The principal coal producing counties are Jefferson, Walker, Bibb, Tuscaloosa, and St. Clair, in the order named. The principal iron ore counties are Jefferson, Tuscaloosa, Franklin and Etowah. The combined value of the pig iron and coke made in Alabama in 1916 was $54,013,799. These values are not included in the total as they are represented in the value of the iron ore and coal produced.

Clay-Working Industries.—These industries yielded products in 1916 valued at $1,520,301 as against $1,193,022 in 1915, an increase of $327,279 or 27.43 per cent. This does not include the value of the raw clay sold, which in 1916 amounted to $51,053, an increase in 1916 of 44.9 per cent.

The center of the clay-working industry is Jefferson county, and Birmingham furnishes the principal market. Vitrified front and fire brick, represent a value of $667,536, or 134.2 of the value of the common brick, while the total output of the brick yard makes up 76.6 per cent of the total value of the clay products of the State. All the fire brick is reported from Jefferson, Baldwin and Calhoun counties, and all the vitrified brick is from Jefferson and St. Clair counties. Clay pits for the manufacture of common brick have been opened in one or more places in thirty-two counties.

The pottery products in 1916 consisted of stone-ware, yellow and Rockingham ware, and red earthen ware, including turpentine cups, and represented a value of $22,805, an increase over 1915 of $7,508, or 49.1 per cent.

Stone.—The quarry products, the greater part of which is limestone, valued in 1916 at $1,202,256, an increase from 1915 of $482,804, or 67.17 per cent. This increase was mainly in the limestone used for flux and in lesser degree in the limestone used for building purposes.

Over 76 per cent of the total value of the stone production in 1916 is that of the limestone. Its most important uses are for furnace flux, concrete, riprap, and for building purposes. The production of marble in 1916 was practically the same as that in 1915. The figures of production cannot be given because of limited number of producers.

Marble holds the second place in the value of quarry products. Beautiful white marble occurring in Coosa and Talladega counties, being extensively used for building work, (both inside and outside). A black marble, which gives promise of future development, has been prospected near Anniston and near Piedmont.

The reader is referred to the body of this Bulletin, under Stone, for further details concerning especially the building stone and marble industries.

Cement.—The cement production of Alabama in 1916 amounted to 1,442,475 barrels, valued at $1,410,104 as against 1,114,386 barrels, valued at $891,473 in 1915. This was an increase of 29.4 in quantity and 58.2 per cent in value.

Lime.—The lime production is not included in that of the limestone. It amounted in 1916 to 67,524 short tons, an increase from the 1915 production of 7,192 tons, or 11.92 per cent. The value of the product is $312,531, an increase from 1915 of $62,304, or 24.89 per cent.

Graphite.—The Alabama graphite is all of the crystalline variety, and the value of the product in 1916 was $492,407 as against $204,572 in 1915, an increase of 140.7 per cent. The Alabama product for 1916 was 54 per cent of the total value of the crystalline graphite for the United States. The great increase in the production and value of the Alabama graphite since 1915, and the installing of a number of new plants in 1916 make it probable that the Alabama production in coming years will represent an even larger proportion of the total U. S. value.

Minor Products.—Alabama produces a small quantity of gold and silver, and other minor products are barytes, bauxite, mill stones, mineral waters, natural gas, sand and gravel, and quartz.

In the following table there is a comparison of the mineral output in Alabama in the years 1915 and 1916. As stated above, the total does not include the value of the pig iron or that of the coke, but it does include the value of the coal made into coke, and of the iron ore sold or used in making pig iron.

Mineral production of Alabama in 1915 and 1916.

PRODUCT	1915				1916			
	Raw.		Derived.		Raw.		Derived.	
	Quantity.	Value.	Quant'y.	Value.	Quantity	Value.	Quantity.	Value.
Coal, short tons	14,927,937	$19,066,033			18,086,197	$24,859,831		
Coke, short tons			3,071,811	$ 8,545,555			4,298,417	$15,019,189
Iron Ore, long tons	5,134,955	6,798,266			6,801,889	10,848,281		
Pig Iron, long tons			2,320,255	23,757,124			2,672,498	38,994,660
Limestone, exclusive of marble		426,266				917,559		
Cement, barrels			1,114,386	891,483			1,442,475	1,410,104
Lime, short tons			60,322	250,227			67,524	312,531
Marble				*				*
Clay, short tons	31,870	35,232			41,479	51,053		
Clay products				1,193,022				1,520,301
Graphite, pounds	3,474,800	204,572			5,226,940	492,407		
Sand and gravel, short tons	924,701	242,336			726,650	184,216		
Bauxite, long tons	*	*			*	*		
Barytes, short tons	*	*			7,631	27,198		
Sandstone, including ganister		30,432				20,995		
Mineral waters, gallons sold	86,499	8,912			103,944	12,174		
Natural gas		*				*		
Gold, fine ounces, Troy			254	5,243			418	8,650
Mica, sheet, pounds			8,400	5,545			14,132	4,955
Mica, scrap, short tons			23	395			65	660
Manganese ore, long tons	*	*			*	*		
Miscellaneous	$328,315				$307,565			
Total†	$29,489,279				$40,973,430			

*Included in Miscellaneous. †Includes Raw and Derived, except Coke and Pig Iron.

STATISTICS OF THE MINERAL PRODUCTION OF ALABAMA FOR 1916

ABRASIVES.

EUGENE A. SMITH.

ALABAMA'S production of abrasives is at present limited to a small number of millstones (chasers†) quarried and made at Dutton, Jackson County; there are, however, several materials in different parts of the State which are sufficiently promising to be worth investigating and thorough testing; the nature and locality of these deposits were treated in Bulletin No. 13, which see.

BARYTES.

(Condensed from Mineral Resources of the United States.)

JAMES M. HILL.

IN 1916 production from deposits in Alabama was reported by 4 operators, as compared with 1 operator in 1915, and the production increased from less than 500 short tons in 1915 to 7,631 short tons in 1916. In 1916 sales were reported by 4 operators whose average price was $3.56, as compared with 1 operator in 1915 who received essentially the same price.

---

†Chasers are larger than the regular millstones. They are used for heavier work, such as grinding quartz, feldspar, barytes, etc., and they run on edge. Though they are made with a diameter as short as 24 inches, they are usually turned out with diameters ranging from 60 to 84 inches, and are as much as 22 inches in thickness. These chasers are run on pans paved with roughly cubical blocks of the conglomerate, with edges about a foot in length. In grinding quartz in such pans the chasers are used in the preliminary crushing; then rough blocks, usually three in number, are either attached to or carried along by lateral arms, which in turn are joined to a vertical revolving shaft. By the circular movement of these blocks the material placed in the pan is ground to powder.

Deposits near Jacksonville, Calhoun County; Vincent, Harper, and Wilsonville, Shelby County; and Leeds, Jefferson County, were under development, and a considerable production was made from the mine in Jefferson County, at which a steam-driven hoisting plant and log washer is operated. The mine is about 5 miles south of Leeds in the flat valley bottom of Little Cahaba River. The Chickamauga (Pelham) limestones (Ordovician), in which the valley is cut,* strike north-northeast and dip southeast at steep angles. The mining has exposed the very rough surface of the underlying blue-gray limestone, in which barite in irregular masses replaces the lime and magnesium carbonates. The barytes is mined from the red residual clay overlying the limestone and some large masses of barytes have been found, though the great bulk of the barytes ranges from 1 to 4 inches in size and is of high grade.

From 1 to 3 miles north of Angle station and about 12 miles northwest of Jacksonville, Calhoun County, there are a series of barytes deposits on which a little development has been done. These deposits lie at the base of white quartzite ridge in red residual clay that is derived from blue-gray magnesian limestone, whose age has not been definitely determined but which is probably Knox dolomite.

In the vicinity of Vincent, Harpersville, and Wilsonville, eastern Shelby County, there are small irregular masses of barytes in the red residual clays derived from limestone of Beekmantown age.† Shipments have been made from several small pockets, and it is reported that at a number of places indications point to larger bodies.

Details concerning the manufacture of ground barytes, of lithopone, and of barium chemicals and their uses are given in Bulletin No. 19 of the Alabama Geological Survey, and in the Mineral Resources of the United States for 1916. E. A. S.

***Butts, Charles, U. S. Geol. Survey Geol. Atlas, Birmingham folio (No. 175), 1910.**

†Butts, Charles, U. S. Geol. Survey Geol. Atlas, Montevallo-Columbiana folio (in preparation).

BAUXITE AND ALUMINUM.

By JAMES M. HILL.*

BAUXITE.

INTRODUCTION.

BAUXITE, the ore of the widely useful metal aluminum, has also an important use in the manufacture of artificial abrasives and of bauxite brick, more properly called high alumina refractories. It is also the basis of an extensive chemical industry, being the crude material from which alum, aluminum sulphate, and several other aluminum salts are made.

DOMESTIC PRODUCTION.

The production of bauxite in the United States in 1916 was 425,100 long tons, having a value at the mines of $2,296,400, an increase over the production in 1915 of 43 per cent in quantity and 52 per cent in value. The poduction from the Georgia, Alabama, and Tennessee field in 1916 was 49,190 long tons, an increase of about 74 per cent, and the Arkansas production of 375,910 long tons showed an increase of approximately 40 per cent.

Apparently the producers of aluminum consumed about 300,000 tons, makers of chemicals about 80,000 tons, and makers of abrasives and refractories about 45,000 tons of bauxite in 1916.

As will be seen by the following table, though the domestic consumption of bauxite in 1916 also increased 43 per cent over the consumption in 1915, domestic deposits were apparently able to supply the whole demand and still leave some bauxite for export. The larger exports were apparently to Canadian aluminum and abrasive makers.

---

*The statistical data in this report were prepared by Miss H. M. Gaylord, of the United States Geological Survey.

Bauxite produced and consumed in the United States, 1912-1916.

YEAR.	DOMESTIC PRODUCTION					
	Georgia, Alabama, and Tennessee		Arkansas.		Total	
	Quantity (long tons)	Value.	Quantity (long tons)	Value.	Quantity (long tons)	Value.
1912	42,566	$191,348	117,299	$577,584	159,865	$768,932
1913	40,370	150,710	169,871	846,988	210,241	997,698
1914	24,071	92,508	195,247	976,686	219,318	1,069,194
1915	28,245	144,345	268,796	1,370,489	297,041	1,514,834
1916	49,190	284,810	375,910	2,011,590	425,100	2,296,400

MARKETS AND PRICES.

The market for bauxite in the United States is east of Mississippi River, and the largest consumers are located at or near the following cities: East St. Louis and Auora, Ill.; Detroit, Mich.; Cincinnati, Ohio; Knoxville, Tenn.; Philadelphia and Erie, Pa.; Niagara Falls and New York City, N. Y.; and Boston, Mass. Recently a number of municipal and industrial waterworks have installed small plants for the manufacture of aluminum sulphate for use in purification of water. It is not believed that this new market will materially affect the industry, as it seems probable that its demand will not be great and that the bauxite used may be of lower grade than that accepted by commercial manufacturers.

Bauxite is graded according to its chemical composition and sold to the various consuming industries on the basis of analysis. Apparently, low silica and titanium content is essential to the aluminum industry, but the iron content may be fairly high, though bauxites low in iron and titanium are preferred by the makers of alum and aluminum sulphate. Makers of abrasives appear to be able to use bauxites lower in grade and containing larger proportions of silica and iron than are permissible in bauxites for other uses, but the majority of abrasives are made from bauxites low in silica and iron. The bauxite used for refractories must apparently be fairly low in iron.

The prices received for bauxite in 1916, as reported by producers, ranged from a low of $4.25 to a high of $6.25 a long ton, the average price for the whole production in 1916 being $5.40 a long ton. During the latter part of the year and early in 1917 higher prices were offered for good grade bauxite from the central Georgia field.

Owing to the freight embargoes placed by various railroads in the last half of 1916 and also to the shortage of cars the producers of bauxite had considerable difficulty in meeting their orders. The exceptionally wet winter was also a handicap to regular production and shipping and, at a few pits in the central Georgia field, work had to be stopped on account of difficult mining or hauling conditions.

OCCURRENCE AND CHARACTER OF BAUXITE IN THE UNITED STATES.

The known commercial bauxite deposits of the United States are in Cherokee, Calhoun, and DeKalb counties, Ala.; Saline and Pulaski counties, Ark.; Wilkinson, Meriwether, and Sumter counties, Ga.; and Hamilton and Carter counties, Tenn.

Clays carrying a large amount of alumina are known in many states, notably central Pennsylvania, northeastern Kentucky, central Indiana, east central Missouri, in the Cretaceous areas of Texas and Alabama, and in the West Coast States. These clays so far as known do not have the characteristics of American bauxite and are not sold as such, though the clay from some of the deposits is used for the manufacture of "high alumina refractories."

All the bauxite mined in the United States is closely associated with kaolin. In the Arkansas field the kaolin is derived from the alteration of syenite in place. In the Tennessee and north Georgia-Alabama fields the origin of the kaolin is not so clear, but it has been formed along faults possibly by the action of circulating waters on the limestone, shale, and quartzitic rocks. In the central-Georgia field the sedimentary kaolins are widespread and were laid down by Cretaceous and Tertiary streams which obtained the materials they carried from the deeply weathered crystalline rocks of the Piedmont region.

In most places there is a distinct gradation from unaltered kaolin through bauxitic kaolin, in which there is a suggestion of pisolitic growth, to bauxite composed entirely of hard pisolites.

Bauxite is not a distinct mineral but rather a rock composed of at least two and possibly three hydrates of alumina, ranging from diaspore ($Al_2O_3 \cdot H_2O$) though theoretical bauxite ($Al_2O_3 2H_2O$) to gibbsite ($Al_2O_3 3H_2O$), iron oxide, water, and silica, and more or less titanium oxide and clay.

The bauxite from all localities in the United States, though it may vary in chemical composition, is on the whole similar in general appearance, with the exception of the "granitic bauxite" of the Arkansas field. The greater part of the American bauxite appears to be made up of rounded pebblelike bodies set in a fine-grained matrix, which may also consist of small rounded particles or may be as fine grained as the finest clay. The pebble or pisolite form is so general that it is the conspicuous characteristic of American bauxite.

The pisolites vary in diameter from a small fraction of an inch to as much as 2 inches, but generally they range from one-fourth to three-fourths of an inch. They are not pebbles in the ordinary sense, as their shape is not due to rounding by running water. The pisolites, when sliced and examined under the microscope, are seen to be made up of concentric layers of amorphous material and are cut by veinlets of a crystalline aluminum mineral. In some deposits the pisolites are hard, in others soft, but it appears to be generally true that the hard pisolite ore is of better grade than the soft.

The matrix of the bauxite in some deposits is soft and claylike, while in other places it is hard and flinty.

The color of American bauxites ranges from light cream through various shades of brown to a deep brownish red, depending on the quantity of iron contained. However, the color is not always a guide to the iron content for some brown or red bauxites are low in iron, the iron being only a stain on the surface and not penetrating the interior of the pisolite.

There is only one way to determine the value of bauxite and that is by chemical analysis, which should show total silica, alumina, titanium oxide, iron oxide, and water. Bauxites of commercial grade should carry at least 52 per cent alumina, though much of that shipped contains from 58 to 65 per cent Al_2O_3, and some material as low as 42 per cent Al_2O_3 is mixed with higher grade ore to bring the average up. Silica and iron should not run above 15 per cent, and the better grades of bauxite contain as low as 1 per cent iron and 3 to 5 per cent silica. Titanium is objectionable, and the content should be below 2 per cent, though much of the central-Georgia bauxite carries nearly 3 per cent TiO_2. The combined water of American bauxites ranges from 15 to 33 per cent. Some of the Arkansas and central-Georgia bauxites are particularly low in iron, titanium, and silica, and are used in the preparation of alumina from which aluminium is made.

A few characteristics, which indicate in a general way the quality of bauxite, may be mentioned, though it is recognized that none of them are dependable. In general, bauxite of fair grade will not show the marks of a hammer when it is hit a glancing blow, though some bauxite has been shipped which can be cut with the hammer. Good bauxite, which has been dried either in the open or in kilns, when thrown on a hard floor has a distinct rattle which bauxitic clay does not have. The pisolites of the lighter-colored bauxites of the central-Georgia field have a peculiar brownish-buff color and look something like horn or flint; they ordinarily can not be broken or marked with the finger nail in bauxites of good grade.

Some measure of the relative quality of dried bauxite can be had by grinding a sample in an agate mortar for half a minute. A bauxite of good grade will be found hard to grind and will stick to the mortar with such tenacity that it will have to be scoured out; a poor bauxite or bauxite clay will grind much more easily and will stick very little, if at all; and clay or kaolin grinds with ease and does not stick to the mortar. Similar results are found if the sample is rubbed on glass and the glass will not be scratched by even high-grade bauxite.

UNITED STATES DEPOSITS.

Arkansas field.—The Arkansas deposits are closely associated with syenitic igneous rocks which outcrop in Saline and Pulaski counties. A large part of the bauxite, according to Mead,* is clearly the result of surface alteration of the syenite in place, though some deposits of transported and reconcentrated bauxites are found in the sedimentary rocks around the syenite center. The syenite first alters to kaolin, which on further action of the surface waters loses silica and changes to bauxite of the "granitic" type, in which the original texture of the syenite is preserved. Further action similar to concretionary growth results in the formation of the usual pisolitic variety of bauxite.

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*Mead, W. —., The occurrence and origin of the bauxite deposits of Arkansas: Econ. Geology, vol. 10, No. 1, pp. 28-54, 1915.

The deposits in Pulaski and Saline counties have been extensively worked by the American Bauxite Co., the Republic Mining & Manufacturing Co., the National Bauxite Co., and the Globe Bauxite Co. Recently the American Bauxite Co. has built a loading station at Bauxippi, Ark., to transship bauxite from cars to river boats for transportation to its plant at East St. Louis.

North Georgia-Alabama-Tennessee field.—In Cherokee County, northeastern Alabama, near Rock Run and Piedmont; in Floyd County, northwestern Georgia, near Rome and Cave Springs; and also near Chattanooga and Keensburg, Tenn., there are large pocket deposits of bauxite which have been worked for a number of years. Some of the pockets have been worked out; others are still in operation; and new deposits are still being found.

The pockets are generally lenticular, ranging from 25 to 300 feet in greatest horizontal dimensions and varying in depth, though the depth is usually comparable to the larger horizontal axis. The pockets are disposed along fault lines, which are clearly marked. Most of them are at the base of grayish quartzite ridges and at the edge of the red clay areas that have resulted from the weathering of the Knox dolomite. The presence of bauxite is usually indicated on the surface by "dornicks" or rounded bowlders of pisolitic bauxite, which are often uncovered in the cultivation of fields.

Not all of the material in the pockets is bauxite, as irregular masses of red and white kaolin are found mixed with the bauxite; but these materials can be separated in mining, as the ore is usually distinctly pisolitic and harder than the kaolin. In some deposits the pisolites are harder than the matrix of the bauxite, and the reverse conditions hold in other places.

All the bauxite mined by the Republic Mining & Manufacturing Co. is kiln-dried before shipment, but none of the other operators dry their ore. Mining at all properties is by hand methods and a number of the properties have no power-driven equipment, though several of the larger pits are equipped with steam pumps and engines for operating the incline plain hoists. A little powder is used to loosen the hard bauxite for ease in picking.

The deposits near Piedmont, Ala., have not been worked for a few years; but the National Bauxite Co. is reported to be reopening the Snider pit about 7 miles north of that place. Near Rock Run, Ala., the Republic Mining & Manufacturing Co. is working several deposits: the largest about 1½ miles east of the town is a pocket about 300 feet in diameter, which is still producing at a depth of 92 feet.

It is reported that bauxite deposits near Fort Payne, DeKalb County, Ala., will be on a producing basis in the near future.

Deposits near Cave Springs, Ga., are under development by the Republic Mining & Manufacturing Co. and Asbury & Sparks, and the first-named company is also shipping from the Booger-Hollow pit near Six Mile.

In the Hermitage area north of Rome, Ga., the Republic Mining & Manufacturing Co. is shipping from a number of deposits on the east side of Armstrong Mountain, near Hermitage, and Asbury & Sparks are developing a pocket about 2½ miles south-southeast of Pinson station.

The bauxite deposits on Missionary Ridge, near Chattanooga, Tenn., were not extensively worked during 1916, though a small output was made. The Carter County deposits in northeastern Tennessee were under development throughout the year. The deposits at both places are quite similar to those near Rome and Cave Springs.

*Central Georgia field.**—The first discovery of bauxite in central Georgia was made in Wilkinson County, and for a time the chief bauxite production of the field was made from deposits near McIntyre and Toomsboro. This area has been gradually extended so that at present bauxite is known to occur westward nearly to Dry Branch, northward to Stephens Potters, southward to Irwinton, and eastward to Oconee River. Deposits near Gordon, McIntyre, Toomsboro, and Irwinton are now under development.

These flat-lying lenticular deposits are at all places associated with nearly white sedimentary kaolins of Upper Cretaceous age. In most places the bauxite lies above the kaolin and the base of the bauxite is not distinct, as it grades into unaltered kaolin. At a few places kaolin overlies a bed of bauxite, into which it grades. Whether the bauxite was deposited as such or is an alteration of the kaolin of recent occurrence is a moot question, but the evidence seems to favor the hypothesis that the bauxite was formed by alteration of the kaolin subsequent to its deposition. The principal operators in this field are the Republic Mining & Manufacturing Co., National Bauxite Co., General Bauxite Co., and the Columbia Kaolin & Aluminum Co.

***Shearer, H. K., A report on the bauxite and fuller's earth of the Coastal Plain of Georgia: Georgia Geol. Survey Bull. 31, pp. 19-140, 1917.**

Since the first bauxite deposits were found in central Georgia, a large field has been opened near Andersonville, in Sumter County, and within the last two years promising deposits have been found in the adjoining parts of Macon and Schley counties. The deposits in this area are similar to those in Wilkinson County in distribution and character, but are found in younger kaolins. These kaolins are Tertiary and probably of the Midway or Claiborne (Eocene) age. The chief operators are the Republic Mining & Manufacturing Co., Kalbfleisch Corporation, Easterlin, and Maynard & Simmons.

Within the last year developments seem to point to a westward extension of the bauxite deposits into Randolph and Stewart counties in western Georgia and possibly into eastern Alabama on a line with known occurrences in adjacent parts of Georgia.

An unusual deposit of bauxite, about 2 miles west of Warm Springs or Bullochville, in Merriwether County, has been worked for a few years. At this place beds of kaolin, which dip steeply north, are exposed by the workings. Two of the beds have been altered to bauxite, one a light-colored variety of good grade from which shipments have been made, the other a dark-red variety which has not been mined. The deposit was operated by the Republic Mining & Manufacturing Co.

ALUMINUM.

DOMESTIC PRODUCTION.

The value of primary aluminum produced in the United States in 1916 was $33,900,000, an increase of 108 per cent over the value of the output in 1915. The value of the total domestic production of new metal and metal produced from scrap in 1916 was $57,330,200, as compared with $22,082,100 in 1915.

MARKET AND PRICES OF ALUMINUM.

In the United States the quoted prices for primary or "virgin" aluminum† ranged from a low of 55 cents a pound in January to a high of 65.12 cents a pound in November, the average for the year being 60.71 cents a pound, as compared with 33.98 cents in 1915. These prices are for small lots and immediate delivery, offered in the open market, and must not be taken to represent the price received by the single producer of primary aluminum in this country. It is reported,† apparently on good authority, that the contract prices of the Aluminum Co. of America to regular consumers ranged from 31 to 37 cents a pound in 1916, as compared with 20 to 31 cents a pound in 1915. The demand for aluminum was very large during 1916, particularly for war materials of various sorts, and it is highly probable that the demands in the near future will be increased considerably.

USES OF ALUMINUM.

No new uses of aluminum of importance were reported during 1916. Apparently the use of aluminum powder in the high explosive "ammonal" greatly increased, though there was a tendency to a restriction of the use of this form of aluminum for precipitation of silver from cyanide solution in metallurgic practice. Aluminum foil has not entirely replaced tin and lead foil for the various uses to which those materials are put.

A large part of the domestic consumption of aluminum is in the form of castings and drawn and pressed ware, which enter into almost every industry. The more important consumption, at present, appears to be in airplanes, automobiles, and war munitions, though immense quantities of cast and pressed aluminum utensils for war, household, and industrial uses are consumed.

Aluminum wire for the transmission of electricity has been replaced by copper to a considerable extent, apparently not so much because of failure of aluminum as because of the high price of the metal as compared with copper.

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†Eng. and Min. Jour., vol. 103, p. 29; also Metal Industry, vol. 15, p. 11, 1917.

Patents for many inventions relating to aluminum—various alloys, methods of fabrication, soldering, and purification of scrap aluminum—have been issued during the last year, copies of which may be obtained from the United States Patent Office.

OTHER BAUXITE PRODUCTS.

Nearly 70 per cent of the domestic output of bauxite in 1916 went into aluminum, but manufacturers of aluminum salts used nearly 19 per cent; apparently 8 per cent was consumed in the manufacture of bauxite abrasives; and 3 per cent was used by makers of "high-alumina refractories," sometimes called bauxite brick.

Within the last two years many foreign and domestic patents have been issued relating to the use of bauxite in the fixation of nitrogen, the manufacture of aluminum salts, and the fabrication of abrasives and refractories. Copies of these patents may be obtained from the United States Patent Office, Washington, D. C.

ALUMINUM SALTS.

The principal aluminum salts made in the United States are alumina, alums, usually ammonium and sodium alums, aluminum sulphate, and aluminum chloride. Alumina is largely consumed in the manufacture of aluminum and no figures of domestic production are available. Alums of various qualities are produced at 9 plants in the eastern United States, the total production of alum in 1916 being 27,257 short tons, valued at $1,177,881, an increase over 1915 of approximately 10 per cent in quantity and of 68 per cent in value.

Aluminum sulphate is made at 18 plants, 6 of which are located at municipal or industrial waterworks, which consume their entire output. The total quantity of aluminum sulphate produced in the United States in 1916 was 153,860 short tons, of which 6,037 short tons did not enter the market but was used for water purification at the place of manufacture. The quantity of domestic aluminum sulphate which entered the market, 147,823 short tons, was less than the quantity in 1915 by 12 per cent, and the total domestic production fell off about 9 per cent. The value of the total production of aluminum sulphate in 1916 was $4,410,741, an increase of nearly 37 per cent over the value of the greater production of 1915.

Aluminum chloride is used for various purposes, among which may be mentioned the refining of mineral oils. This salt was produced at 5 plants in 1916, the total output reported to the Geological Survey being 3,322 short tons, valued at $234,423, or approximately $70 a short ton. This is the first time statistics of production of aluminum chloride have been collected by the Geological Survey.

BAUXITE ABRASIVES.

Bauxite abrasives sold under various trade names, such as alundum, aloxite, carborundum, exolon, and lionite, are made by fusing bauxite in an electric furnace. The fused product is broken, sized, and put into shape for market. Some grades of nearly white artificial aluminum abrasives are believed to be made from alumina. These products are sold in the form of powders, cloth, grinding stones, and wheels of various shapes for a multitude of uses.

The total production of artificial abrasives made from bauxite in 1916 was 30,708 short tons, valued at $2,139,230. Statistics of these products have not been published separately heretofore by the Geological Survey.

HIGH-ALUMINA REFRACTORIES.

There are two classes of high-alumina refractories now on the market. One commonly called bauxite brick is made by mixing various proportions of calcined bauxite or high-alumina clay with a bonding material such as fire clay, sodium silicate, or lime. The material is shaped and then burned at a high temperature in down draft kilns. Refractories of this character are being made by Laclede Christy Clay Products Co., Harbison Walker Refractories Co., Charles Taylor & Sons, and the Massillon Stone & Fire Brick Co. Not all the refractories made by these companies are sold as bauxite brick, and in fact ome do not contain bauxite. It would appear that any reractory brick containing 58 per cent or more of alumina should be included in a statement of the production of high-alumina refractories.

From the best information available to the Geological Survey it would appear that in 1916 bauxite refractories containing 58 per cent or more of alumina to the amount of over 1,000,000 brick, 2½ by 4½ by 9 inches in size, were sold. As has been stated, the refractories are not all sold as brick, but the total quantity is reduced to a comparable figure for publication. The price of these refractories varied from $175 to $380 a thousand, the price apparently depending on the quality of the product.

Refractory brick containing from 45 to 58 per cent alumina were sold in large quantities, the output in 1916 being probably 2,000,000 brick, at prices ranging from $50 upward a thousand.

The second class of high-alumina refractories consists of those made by the electric fusing of bauxite, the molten mass being cast in desired shapes. No information is available concerning the production of this class of refractory, which is being made by some of the companies that make artificial abrasives.

The use of high-alumina refractories seems to be expanding, particularly in the construction of copper, iron, and lead furnaces and of cement kilns.

CEMENT.

Eugene A. Smith.

Portland Cement.

Resources.

ALABAMA contains large supplies of limestone, chalk, cla and shale well adapted to Portland cement manufactur and widely distributed throughout the State. Coal and labo are abundant and cheap, transportation facilities are excellen and many of the best limestone and chalk localities are situate on navigable rivers, giving ready access and cheap water tran portation to Galveston, New Orleans, Mobile, Charleston, an other ports of the Gulf and Atlantic Coasts. This advantag of location was immensely increased with the opening of the Panama Canal for cement plants located in Alabama are more than a thousand miles nearer to the Isthmus than their nearest possible competitors.

The limestones and shales of the northern part of the State lie so close to each other, and above all so close to the great coal mines which must supply the fuel, that the establishment of Portland cement plants near the coal mines would give to this industry in Alabama the same advantages which the proximity of the iron ore, the coal, and the stone has given to the iron industry, and which has placed our State beyond competition.

As a Portland cement mixture, ready for burning, consists approximately of 75 per cent lime carbonate and 25 per cent of clayey matter, the material furnishing the lime carbonate is necessarily of more economic importance than that from which the silica and alumina are derived. In consequence, a Portland cement plant is usually located in the immediate vicinity of a suitable limestone, while the clay or shale required to complete the mixture may be brought some distance.

The limestone formations in North Alabama which can supply the stone adapted for use in cement manufacture are the Trenton or Pelham limestone and the Bangor or Subcarboniferous. In close proximity to both these limestone formations are the shales of the Clinton, Subcarboniferous and Coal Measures.

At the present time there are two cement plants in North Alabama, namely, the Standard Portland Cement Co., located at Leeds in Jefferson County, and the Coosa Portland Cement Co., located at Ragland in St. Clair County. Both of these plants make use of the hard Trenton limestone, and the Standard Cement Co., according to Burchard of the U. S. Geological Survey, uses the shale of the Clinton formation whilst the Ragland Company makes use of the shales of the Coal Measures. Up to the present time no establishment is utilizing the Bangor limestone.

In Middle Alabama the soft, chalky Cretaceous limestone of the Selma Chalk, is the material utilized by the Alabama Portland Cement Co., at Spocari, near Demopolis. The same Company makes use of residual clays overlying and derived from the weathering of the Selma Chalk. During 1915, and since, there was no production from the Demopolis plant.

In Southern Alabama the St. Stephens limestone outcropping east and west across the State, furnishes excellent material for Portland cement manufacture, using either residual clays from decomposition of the limestone, or the clays of the Grand Gulf formation which are almost everywhere in close proximity to the limestone.

Puzzolan Cement.

During the past seven years only one establishment in Alabama, the Southern Cement Company, North Birmingham, has been engaged in the manufacture of slag cement, using the material from the furnaces about Birmingham. The production is included in the returns for Portland cement and cannot be given separately.

Owing to the fact that there was in Alabama in 1916 only one producer of puzzolan cement, and not more than two operating plants in the Portland cement industry, it is necessary to combine the productions of the two industries in order to avoid publishing figures which were given to the Survey in confidence. The tabular results of such a combination are, however, necessarily inconsistent and not to be taken too literally, since the weights per barrel of the two kinds of cement vary.

The total quantity of Portland and puzzolan cement shipped to market in Alabama in 1916, was 1,442,475 barrels, valued at $1,410,104, as compared with 1,114,386 barrels in 1915, valued at $891,473, or an increase in quantity of 328,089 barrels, and an increase in value of $518,631.

Below are given in tabular form the foregoing figures:

Quantity and value of Portland and puzzolan cement marketed in Alabama in 1915 and 1916.

	No. of Producers	Quantity (Bbls.)	Value
1915	3	1,114,386	$891,473
1916	3	1,442,475	1,410,104
Increase		328,089	518,631
Per cent of increase		29.4	58.2

RECOVERY OF POTASH FROM PORTLAND CEMENT MATERIALS.

It has been noticed that the flue dust in a cement plant often contains notable percentage of potash, and efforts have been made to utilize this dust in the extraction of potash. Flue dust from the Standard Cement Plant shows 2½ per cent and above potash, and it is in contemplation to utilize this, and the suggestion is also made to use feldspar in the manufacture. Up to the present time, however, there has been no commercial production of any potash from this source.

CLAY AND CLAY PRODUCTS.

CLAY.

JEFFERSON MIDDLETON AND EUGENE A. SMITH.

CLAY available for the manufacture of clay products is one of the most widely distributed of our minerals. Hence there are clay-working plants scattered over every State and Territory in the Union. Miners of the low-grade clays are usually also the manufacturers, but as the higher grades of ware are reached, the rule is that fewer and fewer manufacturers are also miners, until in the highest grades of ware the rule is that the manufacturer buys and does not mine the clay he uses. The figures given in the following tables represent clay that is mined and not manufactured by the miner, but is sold as clay. The clay thus sold is small in quantity compared with the total production and includes mainly clay used for high-grade pottery and tile, for paper making, and for refractory products.

The total amount of clay mined in Alabama and sold as such in 1916, was 41,479 short tons valued at $51,053. This was an increase in quantity of 9,609 short tons or 30.2 per cent, and of $15,821 or 44.9 per cent in value as compared with 1915.

Below is a table giving the production and value of clay mined and sold in Alabama from 1908 to 1916 inclusive, and a comparison of the production of 1915 and 1916:

Production of clay in Alabama from 1908 to 1916 inclusive, and a comparison of the production in 1915 and 1916.

YEAR	FIRE CLAY		MISCELLANEOUS CLAY		TOTAL	
	Quantity Short Tons	Value.	Quantity Short Tons	Value.	Quantity Short Tons	Value
1908	68,289	$48,983	24,000	$12,000	92,289	$60,983
1909	45,137	35,345	18,271	5,587	63,408	40.932
1910	54,482	32,395	20,600	5,650	75,082	38,045
1911	35,203	29,909	....	....	35,203	29,909
1912	38,552	31,414	4,500	2,000	43,052	33,414
1913	49,901	53,269	*	*	49,901	53.419
1914	27,973	34,607	....	....	27,973	34,607
1915	31,520	34,832	*	*	31,870	35,232
1916	40,235	50,618	1,244	435	41,479	51,053
Increase	8,715	15,786	....	....	9,609	15,821
Percentage	27.6	45.3	....	....	30.2	44.9

*Not divulged but included in total.

In 1915 the average value of the fire clay of Alabama was $1.11 per short ton, and the value of the fire clay production of the State was 1.58 per cent of the total value of the United States production. In 1916 the average value of the Alabama fire clay was $1.26 per short ton, and the value of the Alabama product was 1.37 per cent of the total value of the fire clay produced in the United States.

CLAY PRODUCTS.

The State of Alabama is rich in clays of many kinds, yet its rank as a clay-working State is low, being twenty-fifth in 1916. Its clay products in that year reported by 57 operators were valued at $1,520,301—brick and tile, $1,497,496; pottery, $22,805—an increase of $327,279, or more than 27 per cent. Alabama ranked third in value of silica brick and fourth in its output, and eighth in quantity and tenth in value of vitrified brick or block. Its principal clay product was common brick, valued at $497,446, or 33 per cent of the State total, an increase of $115,354. The quantity of common brick marketed in 1916 was 85,655,000 brick, an increase of 14,974,000 brick. Vitrified brick or block was Alabama's clay product of second value;

25,143,000 brick valued at $311,317, a decrease from 1915 of 3,605,000 in quantity and of $63,070 in value.

Pottery products of Alabama are of minor importance, constituting less than 2 per cent of the value of the clay products of the State. Fire brick, including silica fire brick, was the leading product in Alabama and constituted over a third of the value of the clay products of the State.

Jefferson County was the principal clay-working county, and reported a production valued at $1,060,682, or 70 per cent of the State's total, and an increase of $245,344 compared with 1915. Nearly all of the fire brick and vitrified brick or block produced in the State came from Jefferson County. The principal common brick-producing counties, named in the order of the value of their output were Jefferson, Montgomery, and Talladega.

In tabular form these statistics are given below:

Clay products of Alabama, 1912-1916.

PRODUCT.	1912	1913	1914	1915	1916
Brick:					
Common—					
Quantity	136,989,000	130,923,000	110,781,000	70,681,000	85,655,000
Value	$759,409	$730,148	$638,666	$382,092	$497,446
Average per M.	$5.54	$5.58	$5.77	$5.41	$5.81
Vitrified—					
Quantity	26,480,000	24,183,000	18,679,000	29,018,000	25,143,000
Value	$353,303	$361,722	$248,525	$374,387	$311,317
Average per M.	$13.34	$14.96	$13.31	$12.90	$12.38
Front—					
Quantity	10,629,000	(*)	(*)	5,815,000	6,968,000
Value	$132,088	(*)	(*)	$58,212	$77,470
Average per M.	$12.42	$15.29	$11.42	$10.01	$11.12
Fancy, value	(*)	....	(*)	....	....
Fire, value	$240,484	(*)	$167,021	$145,535	$278,749
Draintile, value	$5,465	$10,802	$6,888	$9,330	(*)
Sewer pipe, value	(*)	(*)	(*)	(*)	(*)
Fireproofing, value	(*)	(*)	(*)	$62,114	$80,523
Tile, not drain, value	....	(*)	....	....	....
Pottery:					
Red earthenware, including turpentine cups, value	$10,990	$11,164	$4,800	$6,741	$13,551
Stoneware and yellow and Rockingham ware, value	$11,223	$8,994	$11,742	$8,556	$9,254
Miscellaneous,† value	$422,322	$968,751	$496,431	$146,055	$251,991
Total value	$1,985,179	$2,091,581	$1,574,023	$1,193,022	$1,520,301
Number of active firms reporting	74	68	70	65	57
Rank of State	17	16	20	24	25

*Included in "Miscellaneous." †Miscellaneous includes drain tile, sewer pipe, stove lining and silica brick.

Value of the clay products of Alabama in 1915 and 1916, with increase.

	BRICK AND TILE	POTTERY	TOTAL
1915	$1,177,725	$15,297	$1,198,022
1916	1,497,496	22,805	1,520,801
Increase:			
Value	319,771	7,508	327,279
Per cent	27.15	49.15	27.43

Pottery products of Alabama are of minor importance, constituting less than 2 per cent of the value of the clay products. Production was reported in 1916 by nine firms. The output was valued at $22,805, an increase of $7,608, or 49.1 per cent as compared with 1915. The products consisted of stone ware and yellow and Rockingham ware, and red earthen ware, including turpentine cups, etc. The latter represents a very notable proportion of the total product. The rank of Alabama in the pottery industry in 1916 was 16.

Comparison of pottery products in 1915 and 1916.

KIND	1915	1916	Increase	Percentage
Red earthenware*	$6,741	$13,551	$6,810	101.02
Stoneware and Rockingham ware	8,556	9,254	$698	8.04
Total	$15,297	$22,805	$7,508	49.08

*Including turpentine cups, vases, etc.

COAL.

E. W. Parker and C. E. Lesher.

Introductory.

THE great Appalachian coal region which furnishes over two-thirds of the coal production of the United States and which extends from Ohio and Pennsylvania on the north in a gradually narrowing belt through eastern Kentucky and Tennessee has its southern terminus in a considerably broadened area that occupies a large part of the northern half of Alabama. The coal-bearing formations of Alabama underlie about 8,400 square miles and are divided into four distinct basins, the Coosa, the Cahaba, and the Warrior, named from the rivers which drain them, and the Plateau, which includes Blount, Lookout, and Sand or Raccoon Mountains. By far the most important basin in area and in production is the Warrior, which includes all of Walker County, most of Jefferson, Tuscaloosa, and Fayette counties, and smaller parts of Blount, Cullman, Winston and Marion counties. The area known to contain coal is approximately 4,000 square miles, or one-half the total coal area of the State, and contributes about 81 per cent of the total production.

There are several distinct coal groups in the basin, the most important of which are the Brookwood, the Pratt, and the Mary Lee, designated by the names of their principal beds. The Mary Lee group includes the Blue Creek, the Jagger, and the Newcastle beds, most of which are mined in places. The Brookwood, the Pratt, and the Mary Lee produce most of the coking coal mined in the State, and more than half of all of the coal mined in the district.

The Cahaba Basin, second in importance, is a long narrow syncline, 68 miles long and about 6 miles wide, southeast of the Warrior, and occupies parts of St. Clair, Jefferson, Shelby and Bibb counties. There are many workable beds, and the total quantity of coal in the basin is large. The production is something over 17 per cent of the total for the State.

The Coosa Basin is a deep syncline east of the Cahaba and parallel with it, extending across Shelby and St. Clair counties. It is also long and narrow, 60 miles long by 6 miles wide. It has not been thoroughly explored, but in different parts of the area from two to twelve beds, 3 or more feet in thickness, have been reported.

The Plateau field embraces parts of Blount, Etowah, DeKalb, Cherokee, Marshall, and Jackson counties, and although it has an area underlain by coal four times that of the Cahaba and the Coosa combined, the resources in Alabama are comparatively small. There are four to six beds locally workable. So far as known, the earliest record of the existence of coal in Alabama was made in 1834. The first statement of production in the State is contained in the United States census report for 1840, in which year the production is given as 946 tons. The census report for 1850 does not mention any coal production for the State, and the next authentic record is contained in the census statistics of 1860, when Alabama is credited with an output of 10,200 short tons. The mines of Alabama were probably worked to a considerable extent during the Civil War, but there are no records of the actual production until 1870, for which year the United States census reports a production of 11,000 tons. Ten years later the production had increased to 323,972 short tons, but the development of the present great industry really began in 1881 and 1882, when attention was directed to the large iron deposits near the city of Birmingham and thus the great "boom" of that city and vicinity was inaugurated. By 1885 the coal production of the State had increased to nearly 2,500,000 tons. Then followed a period of relapse and liquidation, which lasted two years, after which business settled down to a conservative and rational basis and has since developed steadily. In 1902 the coal production of the State reached a total of more than 10,00,000 tons. and reached the maximum of 17,678,522 tons in 1913, since which time there has been a decrease, until 1916, when the maximum of 1913 was exceeded, as may be seen in table below.

PRODUCTION.

The production of coal in Alabama in 1916 was 18,086,197 net tons, valued at $24,859,831, an increase, compared with

1915, of 3,158,260 tons, or 21 per cent, in quantity and of $5,793,788, or 30 per cent, in value. Two-thirds of this increase was in the coal used in the manufacture of coke, the total of which increased 2,098,162 tons* over 1915 as a result of the greatly increased activity of the iron and steel industry in the State.

The production of coal in Jefferson County increased more than 2,250,000 tons, in Walker County the increase was 710,000 tons, and in Tuscaloosa County, 153,200 tons.

A number of factors tended to hold down the production. In July and August abnormally heavy rains and floods caused a number of mines to shut down and greatly interfered with the operation of others. Several mine explosions caused the mines to close. for longer or shorter periods. Although there was an exodus of labor to other fields and industries during the last half of the year the supply of labor was reported to have been deficient throughout the coal fields, the number of men employed increased from 22,591 in 1915 to 25,308 in 1916. The most powerful influence affecting production, however, was the shortage of cars, which began to be felt as early as May and became acute in the last three months of the year.

The increase in the average number of days the mines were worked was notable, from 223 in 1915 to 262 in 1916, a gain of one and a half months' working time. In Tuscaloosa County the number of working days, 293, was almost the maximum possible.

The market for Alabama coal was materially widened in 1916. A readjustment of rates, effective in August, enlarged the market on the west in the Mississippi Valley region, and greater shipments than at any time in the past were made during the last half of the year to the Carolinas, West Virginia, Illinois, and points on the Pacific coast. In December it was announced that the business of the Pittsburgh Coal Co. at New Orleans, amounting to about 500,000 tons a year, had been taken over by Alabama interests, and that new mines were projected to take care of this and other new trade.

The average value of the coal produced in Alabama in 1916 was $1.37 per ton, compared with $1.28 in 1915, an increase that was shared by all producing counties. The average value of all shipments was $1.39 per ton; of coal sold locally, $1.48 per ton; of mine fuel $1.20 per ton; and of coal made into coke at the mines, $1.33 per ton.

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*See current report on coke in Mineral Resources for 1916.

Coal produced in Alabama in 1915 and 1916.

1915

COUNTY.	Loaded at mines for shipment (net tons).	Sold to local trade and used by employees (net tons)	Used at mines for steam and heat (net tons).	Made into coke at mines (net tons).	Total quantity (net tons).	Total value.	Average value per ton.	Number of employees.	Average number of days worked.
Bibb	1,420,639	8,359	105,586	....	1,534,584	$2,093,181	$1.36	2,623	235
Blount	163,018	1,021	1,700	....	165,739	226,716	1.37	368	189
Etowah	173,583	1,974	1,811	....	177,368	259,332	1.46	325	289
Jefferson	5,884,992	329,456	197,806	1,167,249	7,579,503	9,658,836	1.27	10,129	235
Marion	62,653	1,275	4,962	....	68,890	101,318	1.47	199	163
St. Clair	754,569	2,959	16,530	....	774,058	946,446	1.22	786	252
Shelby	550,594	3,290	35,528	....	589,412	989,580	1.68	1,058	227
Tuscaloosa	298,627	9,545	71,277	408,187	787,586	963,910	1.22	1,334	209
Walker	2,886,594	29,925	99,950	205,486	3,221,955	3,784,424	1.17	5,669	197
Winston	26,217	370	40	....	26,627	38,919	1.46	80	191
Small mines*	1,000	1,065	200	....	2,265	3,431	1.51	20	12
	12,222,486	389,239	585,340	1,780,872	14,927,937	19,066,043	1.28	22,591	228

1916

COUNTY.	Loaded at mines for shipment (net tons).	Sold to local trade and used by employees (net tons)	Used at mines for steam and heat (net tons).	Made into coke at mines (net tons).	Total quantity (net tons).	Number of employees.			Average number of days worked.
						Underground.	Surface.	Total	
Bibb	1,384,205	12,281	97,370	....	1,493,856	2,142	411	2,553	255
Blount & Jacks'n	207,986	2,875	1,250	....	212,111	389	36	425	240
Etowah	154,474	2,163	1,964	....	158,601	281	54	335	269
Jefferson	7,428,469	303,661	268,133	1,834,606	9,834,869	10,869	1,793	12,662	275
Marion	68,083	6,021	6,054	....	80,158	180	41	221	215
St. Clair	765,485	3,403	23,282	....	792,170	787	110	897	250
Shelby	578,551	9,705	30,382	....	618,638	938	204	1,142	270
Tuscaloosa	272,307	8,859	59,270	600,360	940,796	1,042	240	1,282	293
Walker	3,540,791	40,744	99,506	250,982	3,932,023	4,739	955	5,694	235
Winston	22,005	410	....	....	22,415	86	11	97	143
Small mines	....	560	....	....	560	....	....	....	....
	14,422,356	390,682	587,211	2,685,948	18,086,197	21,453	3,855	25,308	262

***Includes Jackson County.**

Value of coal produced in Alabama in 1916.

COUNTY.	Loaded at mines for shipment.	Sold to local trade and used by employees.	Used at mines for steam and heat.	Made into coke at mines.	Total value.	Average value per ton.
Bibb	$2,082,201	$23,303	$101,946	....	$2,157,450	1.44
Blount and Jackson	298,204	3,931	1,725	....	303,860	1.43
Etowah	243,471	3,598	3,222	....	250,291	1.58
Jefferson	10,447,149	443,775	362,917	$2,485,957	13,739,798	1.40
Marion	121,128	8,604	6,054	....	135,781	1.69
St. Clair	1,018,356	4,904	26,132	....	1,049,392	1.32
Shelby	1,076,722	17,555	33,707	....	1,127,984	1.82
Tuscaloosa	359,799	21,976	68,151	754,352	1,204,278	1.28
Walker	4,376,689	49,231	102,025	319,255	4,827,200	1.23
Winston	41,332	825	....	....	42,157	1.88
Small mines	....	1,640	....	....	1,640	2.93
	20,015,046	579,342	705,879	3,559,564	24,859,831	1.37
Average value per ton	1.39	1.48	1.20	1.33	1.37	....

In the following table comparative statistics are given covering five years' annual production of coal in Alabama, by counties:

Coal produced in Alabama, 1912-1916, in net tons.

COUNTY.	1912	1913	1914	1915	1916	Increase or decrease, 1916.
Bibb	1,781,335	1,911,026	1,674,846	1,534,584	1,493,856	— 40,678
Blount	146,342	178,958	150,384	165,739	*212,111	+ 46,372
Cullman, Jackson, and Marion	131,505	123,615	81,041	†68,890	†80,158	+ 11,268
Etowah	171,308	137,792	156,909	177,368	158,601	— 18,767
Jefferson	8,174,849	9,028,834	7,936,145	7,579,503	9,834,869	+ 2,255,366
St. Clair	749,753	890,379	752,588	774,058	792,170	+ 18,112
Shelby	496,949	497,569	498,914	589,412	618,638	+ 29,226
Tuscaloosa	880,967	917,305	858,899	787,586	940,796	+ 153,210
Walker	3,547,962	3,967,263	3,450,185	3,221,955	3,932,023	+ 710,068
Winston	18,730	24,951	31,618	26,627	22,415	— 4,212
Small mines	900	830	1,893	†2,265	560	— 1,705
Total	16,100,600	17,678,522	15,593,422	14,927,987	18,086,197	+ 3,158,260
Total value	$20,829,252	$23,083,724	$20,849,919	$19,066,043	$24,859,831	+$5,793,788

*Includes Jackson County. †Marion County only.

The statistics of production in Alabama from 1840 to the close of 1916 are shown in the following table:

Production of coal in Alabama from 1840 to 1916 in short tons.

Year	Quantity	Year	Quantity	Year	Quantity	Year	Quantity
1840	946	1860	10,200	1880	323,972	1900	8,394,275
1841	1,000	1861	10,000	1881	420,000	1901	9,099,052
1842	1,000	1862	12,500	1882	896,000	1902	10,354,570
1843	1,200	1863	15,000	1883	1,568,000	1903	11,654,324
1844	1,200	1864	15,000	1884	2,240,000	1904	11,262,046
1845	1,500	1865	12,000	1885	2,492,000	1905	11,866,069
1846	1,500	1866	12,000	1886	1,800,000	1906	13,107,963
1847	2,000	1867	10,000	1887	1,950,000	1907	14,250,454
1848	2,000	1868	10,000	1888	2,900,000	1908	11,604,593
1849	2,500	1869	10,000	1889	3,572,983	1909	13,708,450
1850	2,500	1870	11,000	1890	4,090,409	1910	16,111,462
1851	3,000	1871	15,000	1891	4,759,781	1911	15,021,421
1852	3,000	1872	16,800	1892	5,529,312	1912	16,100,600
1853	4,000	1873	44,800	1893	5,136,935	1913	17,678,522
1854	4,500	1874	50,400	1894	4,397,178	1914	15,593,422
1855	6,000	1875	67,200	1895	5,693,775	1915	14,927,937
1856	6,800	1876	112,000	1896	5,748,697	1916	18,086,197
1857	8,000	1877	196,000	1897	5,893,770		
1858	8,500	1878	224,000	1898	6,535,283	Total	308,561,914
1859	9,000	1879	280,000	1899	7,593,416		

Coal produced in Alabama, 1912-1916, and increase in 1916.

YEAR	Quantity (Net tons)	Value
1912	16,100,600	$20,829,252
1913	17,687,522	23,083,724
1914	15,593,422	20,849,919
1915	14,927,937	19,066,043
1916	18,086,197	24,859,831
Increase 1916	3,158,260	$5,793,788
Percentage of increase, 1916	+21.1	+30.4

LABOR STATISTICS.

Men employed in the coal mines of Alabama, 1916.

Underground	21,453
Surface	3,855
Total	25,308

Statistics of labor employed in coal mines of Alabama 1908-1916.

YEAR	Number of days active.	Average Number Employed.
1908	222	19,197
1910	249	22,210
1911	227	22,707
1912	245	22,613
1913	255	24,552
1914	226	24,042
1915	223	22,591
1916	262	25,308

Average production per man compared with hours worked per day, and average number of days worked 1910-1916.

Year	8 hours		9 hours		10 hours		All others	Total		Average Tonnage	
	Mines	Men	Mines	Men	Mines	Men	Men	Men	Days Worked	Per Year	Per Day
1910	13	766	36	2,633	134	17,306	1,525	22,230	249	725	2.91
1911	15	550	50	5,345	102	12,628	4,184	22,707	227	662	2.92
1912	11	338	46	4,145	107	13,938	4,192	22,613	245	712	2.91
1913	13	420	36	2,496	135	18,185	3,451	24,552	255	720	2.82
1914	14	646	24	3,546	150	18,115	1,735	24,042	226	648	2.87
1915	13	369	44	4,402	133	17,109	711	22,591	223	661	2.96
1916	9	306	40	2,724	182	20,736	1,902	25,308	262	715	2.73

Strikes and Suspensions.

Statistics of labor strikes in the coal mines of Alabama in 1915 and 1916.

1915			1916		
Number of men on strike	Total days lost	Average number of days lost per man	Number of men on strike	Total days lost	Average number of days lost per man
175	1,290	7	300	920	3

MINING METHODS.

The term "mining method" as used here refers to the manner in which the coal is broken down in the mine and not to the system of mining, or by room and pillar or long wall. In the mine the coal is either blasted from a solid face—shot from the solid—as in hard-rock mining, or is shot loose or otherwise broken down after a preliminary cut into the coal has been made. This cut may be made by hand or by machine. Underground methods are therefore classified as shot from the solid, mined by hand, and mined by machines. An increasing quantity of coal is being recovered each year by stripping the cover from the bed in open pits by steam shovels. The bed thus exposed is for the most part shattered by powder and shoveled into cars by hand, although in places it is picked up directly by small steam shovels.

Opposition to shooting from the solid has developed, because it is injurious to the mining property in that the unusual charges of powder weaken the roof and pillars, which increases the liability to falls of roof and coal, the most prolific cause of fatal accidents to coal miners. Another objection to this method is that the heavy charges of powder required to blow down the coal where it has not been previously undercut or sheared cause the production of a very high proportion of fine coal and render the lump coal so friable that it disintegrates in handling and in transportation. With the growing use of mechanical stokers and of powdered coal the latter objection is losing much of its force, but the danger attending the method has been in no wise diminished, and it is forbidden by law in some of the coal-mining States. There was a slight increase in the total output shot from the solid in 1916 compared with 1915.

Statistics of bituminous coal recovered from steam shovel pits, appear for the first time in 1916. One shovel only was active in Alabama in 1915.

Quantity and percentage of coal mined by different methods in Alabama in 1915 and 1916, in short tons.

YEAR	Mined by hand	Percentage	Shot off the solid	Percentage	Mined by machines	Percentage	From steam shovel pits	Percentage	Not reported	Percentage	Total production
1915	4,634,815	31.0	5,001,653	33.5	5,285,133	35.4	*	....	6,336	0.1	14,927,937
1916	5,658,300	31.3	6,547,225	36.2	5,802,150	32.1	75,462	0.4	3,060	....	18,086,197

*Included in Not Reported.

Bituminous coal mined by machines in Alabama in 1915 and 1916.

YEAR	Number of machines in use	Number of tons mined by machines	Total tonnage of Alabama	Percentage of total product mined by machines
1915	373	5,285,133	14,927,937	35.4
1916	320	5,802,150	18,086,197	32.1

COAL-WASHING OPERATIONS.

Not all coal can be cleaned by hand picking. Some coal beds or parts of beds have layers or benches of slate and bone or contain more than the allowable quantity of sulphur in the form of iron pyrite so thoroughly mixed with the coal that crushing is necessary to free the coal from the refuse. To clear such coal washing is resorted to and the coal, being lighter than the refuse, is separated by currents of water. Coal is also cleaned in the dry state.

Alabama leads in the quantity of coal washed, almost 42 per cent of the total quantity, so treated in 1916, being from that State.

Coal washed at the mines in Alabama in 1915 and 1916, with quantity of washed coal and of refuse obtained from it, short tons.

YEAR	Quantity of coal washed	Quantity of cleaned coal	Quantity of refuse	Percentage of cleaned coal to total state output
1915	8,734,475	7,920,122	814,353	53.0
1916	10,695,700	9,742,467	953,233	53.9

AVERAGE VALUE OF ALABAMA COAL.

Average value per short ton for coal at the mines in Alabama since 1908.

1908	1909	1910	1911	1912	1913	1914	1915	1916
$1.26	$1.19	$1.26	$1.27	$1.29	$1.31	$1.34	$1.28	$1.37

COKE.

PRODUCTION AND CONSUMPTION.

The production of coke in Alabama in 1880, 1890, 1900 and annually from 1910 to 1916 is shown in the following tables:

Statistics of the manufacture of coke in Alabama, 1880-1916.

YEAR	Establishments	OVENS		Coal used (short tons)	Yield of coal in coke (per cent)	Coke produced (short tons)	Total value of coke at ovens	Value of coke at ovens, per ton
		Built	Building					
1880	4	316	100	106,283	57.0	60,781	$ 183,063	$3.01
1890	20	4,805	371	1,809,964	59.0	1,072,942	2,589,447	2.41
1900	30	6,529	690	3,582,547	58.9	2,110,837	5,629,423	2.67
1910	43	10,132	340	5,272,322	61.6	3,249,027	9,165,821	2.82
1911	44	10,121	280	4,411,298	62.6	2,761,521	7,593,594	2.75
1912	46	10,208	100	4,585,498	64.9	2,975,489	8,098,412	2.72
1913	46	10,284	20	5,218,323	63.6	3,323,664	9,627,170	2.90
1914	38	9,318	0	4,678,196	65.9	3,084,149	8,408,443	2.73
1915	38	9,318	0	4,695,938	65.4	3,071,811	8,545,555	2.78
1916	....	*9.549	97	6,794,100	57.9	4,298,417	15,019,137	3.45

*Includes 300 Semet-Solvay, and 443 Koppers ovens..

Comparison of the production and value of coke in Alabama in 1915 and 1916.

	Number of ovens	Coal charged (short tons)	Coke produced (short tons)	Total value of coke at ovens	Percentage of total U. S. value
1915	9,318	4,695,938	3,071,811	$8,545,555	8.10
1916	9,549	6,794,100	4,298,417	15,019,139	....
Increase	231	2,098,162	1,226,606	6,473,584	....
Percentage	2.48	44.68	39.93	75.51	....

Coke produced in beehive and by-product ovens in Alabama in 1915 and 1916.

YEAR	BEEHIVE COKE				BY-PRODUCT COKE				TOTAL		
	Active ovens	Coal used (net tons)	Coke produced (net tons)	Value of coke at ovens	Active ovens	Coal used (net tons)	Coke produced (net tons)	Value of coke at ovens	Coal used (net tons)	Coke produced (net tons)	Value of coke at ovens
1915	2,506	1,708,228	1,001,477	$3,086,656	732	2,987,710	2,070,334	$5,458,899	4,695,938	3,071,811	$8,545,555
1916	4,269	3,158,417	1,828,067	5,828,057	730	3,635,683	2,470,350	9,191,082	6,794,100	4,298,417	15,019,139
Increase or decrease	+1,763	+1,450,189	+ 826,590	+2,741,401	— 2						
Percentage	70.35	84.89	85.53	88.81	0.27						

Coke consumed in Alabama in 1915-1916, exclusive of imports, in net tons.

YEAR	Furnace	Foundry	Other
1915	2,870,378	110,901	......
1916	4,048,471	158,339	747

1916

SOURCE	Furnace	Foundry	Domestic fuel, etc.
Alabama	4,048,471	157,323	393
Georgia, Tennessee, Virginia, West Virginia	....	1,016	354
	4,048,471	158,339	747

VALUE.

Quantity (net tons) and value of coke produced in Alabama, 1912-1916.

	1912	1913	1914	1915	1916	Increase	Percentage		
							Total	Beehive	By-product
Quantity	2,975,489	3,323,664	3,084,149	3,071,811	4,298,417	1,226,606	39.9	82.5	19.3
Value	$8,098,412	$9,627,170	$8,408,443	$8,545,555	$15,019,139	$6,473,584	75.8	88.8	68.4

Average value, per short ton and percentage of coke from coal, in Alabama, 1911-1916.

	1911	1912	1913	1914	1915	1916
Average value	$2.75	$2.72	$2.90	$2.73	$2.78	$3.49
Percentage yield	62.6	64.9	63.6	65.9	65.4	63.3

Quantity and value of coal used in the manufacture of coke in Alabama in 1915 and 1916, and quantity and value of same per ton of coke.

YEAR	Coal used (short tons)	Total value of coal	Value of coal per ton	Quantity of coal per ton of coke (short tons)	Value of coal to a ton of coke
1915	4,695,938	$6,955,215	$1.48	1,529	$2,268
1916	6,794,100	11,000,238	1.62	1,581	2,561

COKE OVENS.

Coke ovens in Alabama, 1915 and 1916.

YEAR	Active		Idle		Total		Abandoned	
	Beehive	By-product	Beehive	By-product	Beehive	By-product	Beehive	By-product
1915	2,506	732	6,062	18	8,568	750	....	....
1916	4,269	730	4,537	13	8,806	743	62	7

Coke ovens in Alabama at the end of 1911-1916.

YEAR	Beehive	By-product
1911	9,781	340
1912	9,588	620
1913	9,584	700
1914	8,568	750
1915	8,568	750
1916	8,806	743

Record of by-product ovens in Alabama, 1910-1916.

YEAR	Built	Building
December 31, 1910	280	340
December 31, 1911	340	280
December 31, 1912	620	100
December 31, 1913	700	20
December 31, 1914	750	0
December 31, 1915	750	0
December 31, 1916	743	97

Complete list of retort coke-oven plants of Alabama, Jan. 1, 1917.

TOWN	System	Name of company owning plant	Date put in operation	Number of ovens	Uses of coke	Uses of surplus gas
Ensley	Semet-Solvay	Tennessee Coal, Iron & R. R. Co.	1898-1902	240	Blast furnace	Boiler fuel.
Fairfield	Koppers	Tennessee Coal, Iron & R. R. Co.	1912	280	Blast furnace	Boiler fuel and open hearth furnace.
Tuscaloosa	Semet-Solvay	Central Iron & Coal Co.	1906-1914	60	Furnace foundry and heating	Boiler fuel.
Woodward	Koppers	Woodward Iron Co.	1911-1914	163	Blast furnace	Fuel.

CHARACTER OF THE COAL USED.

Ninety-six and five-tenths per cent of the coal used in the manufacture of coke in Alabama is washed before being charged into the ovens. In 1916, out of a total of 6,794,100 tons of coal made into coke, 6,555,251 tons were washed. Of the washed coal used 4,202,344 tons were slack, and 2,352,907 tons were mine run.

The unwashed mine run coal was 238,849 tons, while there was none of the slack unwashed.

The character of the coal used in the manufacture of coke in Alabama in 1890, 1900, and for the last seven years, is shown in the following tables:

Character of coal used in the manufacture of coke in Alabama, 1890-1916, in short tons.

YEAR	Run of Mine		Slack		Total
	Unwashed	Washed	Unwashed	Washed	
1890	1,480,669	0	206,106	123,189	1,809,964
1900	1,729,882	152,077	165,418	1,535,170	3,582,547
1910	771,931	1,308,085	0	3,192,306	5,272,322
1911	693,135	1,295,109	2,937	2,420,117	4,411,298
1912	747,805	896,421	18,793	2,922,979	4,585,498
1913	868,659	684,223	0	3,665,441	5,218,328
1914	703,241	2,069,638	0	1,905,317	4,678,196
1915	158,480	1,522,149	47,061	2,968,248	4,695,938
1916	238,849	2,352,907	0	4,202,344	6,794,100

Character of coal used in the manufacture of coke in Alabama in 1914, 1915, and 1916, in short tons.

Year	Run of mine		Slack		Total			
	Unwashed	Washed	Unwashed	Washed	Unwashed	Percentage	Washed	Percentage
1914	703,241	2,069,638	0	1,905,317	703,241	15.0	3,974,955	85.0
1915	158,480	1,522,149	47,061	2,968,248	205,541	4.4	4,490,397	95.6
1916	238,849	2,352,907	0	4,202,344	238,849	3.5	6,555,251	96.5

RANK OF THE STATES IN COKE PRODUCTION.

Coke was produced in 1916 in 22 states; in 5 only beehive coke was made. In the other states either the whole product came from by-product ovens, or both methods of coke-making were employed. In total output Pennsylvania heads the list, with Alabama, Indiana, and West Virginia following in order. As regards the production of coke from by-product ovens the first five states rank Pennsylvania, Indiana, Alabama, Illinois, while West Virginia ranks as No. 15.

The rank of the coke-producing states in respect of the total and of by-product output for the years 1912-1916 is shown in the following table:

Rank of the States in the production of coke, 1912-1916.

STATE	1912		1913		1914		1915		1916	
	Total	By-product	Total	By-product	Total	By-product	Total	By-product	Total	By-product
Pennsylvania	1	1	1	1	1	1	1	1	1	1
Alabama	2	4	2	3	2	3	2	3	2	3
Indiana	3	2	3	2	3	2	3	2	3	2
Illinois	5	3	5	4	4	4	4	4	5	4
West Virginia	4	12	4	12	5	14	5	13	4	15
Michigan	11	8	11	8	9	6	6	5	10	6
Ohio	13	11	14	11	11	9	7	7	6	5
New York	8	5	8	5	12	8	8	6	11	7
Colorado	6	......	7	......	7	......	9	......	8	......
Virginia	7	......	6	......	6	......	10	......	7	......
Wisconsin	9	6	9	6	8	5	11	8	12	8
Kentucky	18	......	16	14	13	11	12	12	9	12
Massachusetts	10	7	10	7	10	7	13	9	13	9
New Mexico	12	......	12	......	14	......	14	......	14	......
Utah	15	......	15	......	15	......	15	......	17	......
Maryland	16	9	18	10	19	13	16	10	15	10
New Jersey	17	10	17	9	17	10	17	11	20	14
Tennessee	14	......	13	......	16	......	18	17	18	16
Washington	20	......	20	......	20	15	19	16	21	17
Missouri	......	......	......	......	......	......	20	14	19	13
Minnesota	19	13	19	13	18	12	21	15	16	11
Georgia	21	......	21	......	21	......	22	......	22	......
Kansas	22	......	......	......	......	......	......	......	......	......

GOLD AND SILVER.

By JAMES M. HILL.

IN 1916 there were mined in Alabama 418.44 ounces of gold, valued at $8,650, and 53 ounces of silver, valued at $35, an increase of 164.81 ounces of gold and of 41 ounces of silver in 1916 over 1915. The production in 1916 came from 3 placer mines and 2 deep mines in Chilton, Cleburne, Talladega, and Tallapoosa counties, as compared with 2 placers and 1 deep mine in 1915. There were 11,063 tons of ore treated by amalgamation at the two deep mines in operation, the greater part being from Tallapoosa County.

The discovery of lead ore is reported near Jamestown, Cherokee County, and near Huntsville, Marshall County.

Other details concerning the Gold and Silver production in Alabama may be seen in the tables following:

Mine production of gold and silver in Alabama in 1916.

GOLD		SILVER		Increase in value as compared with 1915	
Quantity Fine Ounces	Value	Quantity Fine Ounces	Value	Gold	Silver
418.44	$8,650	53	$35	$3,407	$29

Mine production of gold and silver in Alabama in 1916, by sources, in fine ounces.

GOLD		SILVER	
Placers	Dry or siliceous ores	Placers	Dry or siliceous ores
37.59	380.85	23	30

Fuller accounts of the occurrences and former activities in the mining and milling of gold and silver in Alabama will be found in our statistical reports for 1914 and 1915.

GRAPHITE.[*]

By HENRY G. FERGUSON.

INTRODUCTION.

NATURAL graphite may be either crystalline or amorphous. The term crystalline or flake graphite is commonly understood to mean graphite in crystals large enough to be visible to the naked eye; much of the so-called amorphous graphite shows a crystalline structure under the microscope. Crystalline graphite occurs either in veins, as in the Ceylon deposits, or as flakes disseminated through the country rock, as in most of the crystalline graphite deposits of the United States.

Most deposits of amorphous graphite are the result of the alteration of coal beds by the intrusion of igneous rocks. Amorphous graphite is also made artificially by means of the electric furnace.

USES.

The peculiar physical properties of graphite—infusibility, chemical inertness, high conductivity, extreme softness, and low specific gravity—fit it for many uses, such as the manufacture of crucibles and other refractory products, lubricants, lead pencils, paint, foundry facings, as a preparation to loosen boiler scale, as polish for punpowder, and for various applications in electrical work.

Graphite is now employed as a lubricant in the manufacture of self-lubricating metals. Molten metal is forced at high pressure into graphite, and the resulting mixture contains about 60 per cent by weight or 25 per cent by volume of the metal. For most purposes graphite is impregnated with babbitt metal. In another process metallic oxides are mixed with graphite and heated to a high temperature. The oxides are reduced to the metallic state by the graphite and the resulting alloy contains an intimate mixture of particles of graphite.‡ The metallized graphite is machined into bushings which in light service are independent of oil lubrication. In the most favorable usage the bushing itself revolves, as in loose pulleys. Graphite metallized with copper is used for many electrical appliances, such as contacts and brushes for motors, generators, and converters.

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[*] Part of the material in the following pages is derived from the annual reports on graphite by E. S. Bastin published in the volumes of Mineral Resources of the United States and from Geology of the graphite deposits of the United States, also by E. S. Bastin (U. S. Geol. Survey Bull.—, in preparation.)

[†] Yates, R. F., Combining graphite with alloys in the manufacture of self-lubricating metal: Sci. Am., vol. 115, pp. 318-319, Oct. 7, 1916.

[‡] U. S. patent No. 1071044, 1913.

By far the most important use of graphite is in the manufacture of crucibles, and for this reason graphite is a mineral resource of vital importance in time of war, and American producers of flake graphite have greatly increased their production. The makers of crucibles largely increased their output in 1916, though unable to take full advantage of the increased demand because of the difficulty in obtaining adequate supplies of graphite of crucible grade.

Most makers of crucibles prefer to use Ceylon graphite mixed with 10 to 25 per cent of American flake. The principal reason for the preference for Ceylon graphite is that the flat flake of the domestic graphite has a far greater surface area in proportion to its volume than the more nearly cubical fragments of Ceylon graphite and hence requires a proportionately greater amount of clay as a binder. Some difficulty was experienced in finding a domestic clay to take the place of the Bavarian clay formerly used, but satisfactory clays have now been found. In emergency, however, it should be possible to make satisfactory crucibles entirely from domestic graphite and domestic clay. It appears that in Germany the Bavarian graphite, which is similar to the American flake, is now pressed into lumps and used in place of the Ceylon product. Improved finishing methods may make possible the use of a larger proportion of American flake without further treatment.

For most purposes amorphous graphite, either natural or artificial, may be used with as good effect as the crystalline variety, but for the manufacture of crucibles crystalline graphite is considered essential, as the flakes should be large enough to add to the binding power of the clay.

PRODUCTION AND IMPORTS.

CRYSTALLINE GRAPHITE.

The great increase in the manufacture of brass and crucible steel during the last three years has called for a tremendous increase in the use of crystalline graphite. This has been met for the most part by largely increased imports, particularly from Ceylon, and only in part by the expansion of the domestic graphite industry.

Crystalline graphite imported and produced in the United States, 1911-1916.

QUANTITY (Short Tons)

	1911	1912	1913	1914	1915	1916
Imports:*						
Ceylon	13,119	16,791	16,996	8,755	14,491	26,232
Other countries	2,384	2,819	2,382	2,328	4,504	5,828
	15,503	19,610	19,378	11,083	18,995	32,060
Domestic production	2,395	1,772	2,532	2,610	3,537	5,466
Total available supply	17,898	21,382	21,910	13,693	22,532	37,526
Per cent represented by domestic production	13.4	8.3	11.6	19.1	15.7	14.6

VALUE

Imports:*						
Ceylon	$1,132,678	$1,379,587	$1,674,764	$962,593	$1,746,153	$6,013,362
Other countries	83,124	127,347	160,766	144,599	303,639	920,369
	1,215,802	1,506,934	1,835,530	1,107,192	2,049,792	6,933,731
Domestic production	256,050	187,689	254,328	285,368	417,273	914,748
	1,471,852	1,694,623	2,089,858	1,392,560	2,467,065	7,848,479
Per cent represented by domestic production	17.5	11.1	12.2	20.5	16.9	11.7

*From records of the Department of Commerce.

As usual, the greater part of the domestic crystalline graphite was produced by Alabama, New York, and Pennsylvania. The production of these States was all of the variety known in the trade as flake graphite, which occurs as small flakes forming 3 to 10 per cent, by weight, of crystalline schists. In addition, crystalline graphite, resembling in a general way the Ceylon graphite, was produced in Montana, and a small quantity of flake graphite was mined in California and Texas. The quantity of crystalline graphite produced in 1916 exceeded that for any previous year and was an increase of 55 per cent in quantity and of 119 per cent in value over 1915. The number of producers of crystalline graphite was 7 in Alabama, 1 in California, 1 in Montana, 3 in New York, 5 in Pennsylvania, and 1 in Texas.

Crystalline graphite produced in the United States, 1916

	QUANTITY		VALUE	
	Pounds	Percentage of total	Amount.	Percentage of total
Alabama	5,226,940	48	$492,407	54
Pennsylvania	1,095,716	10	103,377	11
California, Montana, New York, Tex.	4,609,333	42	318,964	35
	10,931,989	100	914,748	100

The principal source of imported graphite is the island of Ceylon, although of late years Madagascar graphite has attained considerable importance. During the greater part of 1916, however, war conditions prevented the export of Madagascar graphite to this country. During 1914 and 1915 the imports from Ceylon were below the normal quantity, owing chiefly to the high freight rates and scarcity of ships; but they increased greatly in 1916. Imports from Canada in 1916 were greatly in excess of those of previous years.

AMORPHOUS GRAPHITE.

Amorphous graphite is suitable for all purposes for which graphite is used except the manufacture of crucibles. As it does not enter to any large degree into the manufacture of munitions, the war has not greatly affected either price or production. Moreover, both artificial graphite and crystalline graphite in particles too small for crucible manufacture are adapted to practically all uses to which natural amorphous graphite can be put. The uses of amorphous graphite vary greatly with the purity of the substance mined. For paint and foundry facings a high degree of purity is not essential; but for lubricants, pencils, and electric purposes high-grade material is necessary. The better grades of amorphous graphite are imported from Mexico and Chosen, and the imports, like those of crystalline graphite, greatly exceed the domestic production.

MARKETS AND PRICES.

Ceylon graphite of the better grades is more largely used by crucible makers than domestic flake graphite and, even in normal times, commands a higher price. During the last three years the tremendous increase in crucible manufacture has caused a demand for the Ceylon product greatly in excess of the available supply and the price has constantly increased. The sharp increase of price for all grades of Ceylon graphite in 1916 over that for previous years is in part due to the fact that a much larger proportion of the highest-grade product was imported. In March, 1917, the prices of Ceylon graphite, ex-dock, New York, were approximately as follows: No. 1 lumps, 28 to 30 cents a pound; No. 1 chip, 19 to 21 cents; No. 1 dust, 11 to 12 cents.

The prices paid for the highest grade of domestic graphite at the mines in 1916 ranged from 10 to 16 cents a pound. The New York prices varied greatly according to the demand. In the summer of 1916 the price was as high as 18 cents a pound. At the end of the year increased imports from Ceylon reduced the price, and in March, 1917, domestic graphite of good grade could be bought for 12 or 13 cents a pound. The prices paid at the mines for the highest grade product, in cents a pound, have been as follows: 1911 and 1912, 6 to 7; 1913, 6 to 8; 1914, 6½ to 8; 1915, 7 to 10; 1916, 10 to 16.

Average prices of all graphite imported from Ceylon and all crystalline graphite produced in this country, including dust as well as flake, have been as follows:

Average prices of graphite, 1911-1916, in cents per pound.

	Ceylon	Domestic
1911	4.3	5.3
1912	4.1	5.3
1913	4.9	5.0
1914	4.5	5.5
1915	6.4	5.9
1916	12.0	8.4

The sharp increase in the value of the Ceylon graphite imported in 1916 is due largely to the fact that, owing to the high freight rates and scarcity of ships, the higher-grade material formed a larger proportion of the total.

Domestic amorphous graphite brought widely varying prices according to the grade of the product, but in general not greatly in advance of prices before the war. Amorphous graphite from Chosen averaged about $45 a ton on the New York market, a price due largely to the prevailing high freight rates.

The present condition of the graphite market is, with respect to crystalline graphite, the result of a greatly increased demand on account of the war. The high prices have resulted in a large increase in the number of new companies, particularly in Alabama. It is inevitable that after the war prices will be much reduced, but the more efficiently managed companies will probably be able to operate at a profit with prices even lower than those of 1913.

In order to assist producers in marketing their product, the Geological Survey has prepared a list of firms known to be purchasers of domestic graphite. This will be mailed free on request to the Director, United States Geological Survey.

ALABAMA.

GENERAL FEATURES.

The graphite industry in Alabama advanced notably during 1916, the production being greater by 50 per cent in quantity and 141 per cent in value than that of 1915. There has, moreover, been a great increase in exploitation during the last few months, and therefore it seems desirable to describe the graphite deposits of the State at greater length than has been done in previous reports.

In addition to the 7 companies which produced graphite in 1916, 3 of which were new producers, 2 companies began production between January 1 and April 1, 1917, and 23 others expect to begin operations during the next few months. It is probable that the Alabama output for 1917 will be more than double that for 1916.

The graphite occurs in a graphitic schist which forms lenses in a series of metamorphic rocks traversing parts of Clay, Coosa, and Chilton counties. Quartz is the principal constituent of the graphite-bearing schist, with subordinate amounts of pyrite, mica (biotite), and apatite. These bands of schist rarely exceed 100 feet in thickness and appear to be fairly continuous, though prospecting has not yet proceeded sufficiently to establish their continuity over long distances. The average graphite content of the ore in terms of graphitic carbon is 3 or 4 per cent, though in some places analyses show a carbon content of 5 or 6 per cent. In nearly every deposit the graphite schist is intruded by small stringers of pegmatitic granite. These contain only a little graphite, but appear to have caused a more intense recrystallization of the original carbon in the intruded rock, which has resulted in a coarsening of the flake in the immediate vicinity and possibly in an actual enrichment in the graphite content. The wall rocks are in most places schists that are similar in type to the graphite-bearing schist but contain less graphite and more mica. At a few localities, however, one wall consists of hornblende schist, probably an altered basic intrusive. No graphite is found where the hornblende schist is intruded by granite—an evidence that the carbon from which the graphite is derived is not a product of the granite intrusion. The graphite schists commonly crop out along ridges, and, as a rule, the overburden is very light. The pyrite of the deposits is in most places completely oxidized to the depth of 50 to 60 feet. Besides removing this very objectionable constituent of the ore, weathering has softened the rock and lessened the coherence between the graphite and the other minerals, which facilitates both mining and concentration. The unoxidized schist is avoided as far as possible in mining operations, as it is hard to crush, and the pyrite can be completely eliminated from it only with difficulty. It would, however, be perfectly feasible to treat this "blue rock" should necessity arise.

The following recent articles are of interest in regard to the graphite deposits of Alabama:

Prouty, W. F., Flake graphite in Alabama: its location, its history, and its value to the State: Birmingham Age-Herald, January 28, 1917.

——— Extent and development of flake graphite resources of Alabama: Manufacturers' Rec., April 19, 1917, pp. 66-67.

Pratt, J. H., Alabama graphite deposits: Manufacturers' Rec., March 22, 1917, p. 58.

Herr, Irving, Clay County graphite district of Alabama: Eng. and Min. Jour., vol. 103, pp. 693-697, April 21, 1917.

MINING AND CONCENTRATION.

Mining is done in open cuts, and in common practice a 30-foot face is broken down with a single charge of dynamite and the material loaded into cars. The large blocks are broken by hand or by small charges of powder. In loading a certain proportion of low-grade material is discarded. The deposits with steep dips are, of course, at an advantage over others in the costs of mining.

Milling methods are much the same in most of the mills and may be described briefly. Large bins have been installed in most of the newer mills to allow steady runs even in wet weather, as it is of great advantage to have the ore as dry as possible. The ore passes to a jaw crusher, where it is broken to about 1-inch size and next to a rotary cylindrical drier. In some mills rolls are used before drying. The dry ore is next crushed in rolls and screened, the oversize going back to the rolls and the fines passing to the water-flotation concentrator. In some mills the crushed ore first passes through an air separator in which a suction fan removes the graphite and dust and leaves the coarser sand behind. This process is open to the objection that a certain quantity of coarse flake is left behind with the sand and some fine graphitic dust is inevitably lost. Where a middling product is made, it is returned to the rolls. In some of the newer mills the graphitic sands pass from the drier into cooling bins, where they remain 24 hours, the bins being drawn on alternate days. The reason for this is that water flotation has been found to act more effectively on cool material.

The principal concentration process is water flotation. The flotation separator is a rectangular trough 5 to 9 feet long, 6 to 10 inches wide, and 12 to 18 inches deep. This trough is filled with water, which is supplied in a thin curtain from the top along the entire length of one side and overflows into a launder on the other side. The amount of water is regulated so that the flow across the trough shall be as smooth and free from ripples as possible. The graphitic sand is fed in a thin stream onto the moving water surface. In a few mills the sand is fed over a revolving shaft which distributes the feed more evenly. Most of the sand sinks, and the graphite flakes, together with a little mica and fine grit, float off on the moving water. A recent modification of the flotation separator is circular in form and about 6 feet in diameter, and in it the sand is fed at the apex of a stationary or revolving cone.

The launders carry the concentrates to shaking screens, on which they are freed from surplus water. Fine sprays falling on these screens wash out a part of the fine grit. In one mill a hexagonal reel is used instead of the shaking screen. The concentrates are next dried on a concrete drying floor heated by steam or in double-chambered rotary cylindrical driers. In some mills the concentrates then pass through another air separator. This removes whatever coarse grit has been floated with the graphite.

The finishing process consists of grinding in burrstone mills and screening in bolting reels or inclined shaking screens of the kind used in flour mills. The purpose of the burr mill is to break the grains of quartz so that they will pass through the finest screen with the dust while the No. 1 and No. 2 flake remains as oversize from the different screens. In a few mills electrostatic separation has been tried in place of burr mills for the final finishing, but in the Clay County mills it has not proved satisfactory.

Three mills use processes different from that outlined above. The new mill of the Alabama Graphite Co. uses a wet process for the preliminary concentration. The material is crushed in jaw crushers and is then fed with water into the muller and from that to a log washer, in which the sands are screened toward the discharge at the upper end while the graphite flakes float off at the lower end. The dewatering and finishing process is the same as that outlined above. The Ceylon Co. uses an oil-flotation process and the Flaketown Graphite Co. uses a dry process throughout.

The usual Alabama system as outlined above is open to the following objections:

1. The recovery is low; in most mills the total of the finished product amounts to about 2 per cent of the ore handled. As none of the final product is pure graphite, this probably means a total saving of not over 60 per cent of original graphite content.
2. The quantity of dust is too great in proportion to the quantity of No. 1 flake produced. The proportion of different products varies from 40 to 50 per cent of No. 1 flake, 25 to 15 per cent of No. 2 flake, and 40 to 35 per cent of dust. Grinding dry in the muller or Chile mill and the final grinding in the burr mills probably breaks the flake badly.
3. Under the present system the ore must be dried before the graphite can be separated by water flotation and the concentrates must be dried again before finishing. A wet concentration process would eliminate the preliminary drying.
4. There is no uniform standard for No. 1 flake. A few producers guarantee a 90 per cent carbon content but the majority produce No. 1 flake carrying about 85 per cent.
5. The dust-filled mills can not fail to be injurious to the health of the workers.

MINES.

The following notes in regard to mining operations are largely the result of the writer's observations during a brief trip to Clay and Coosa counties in April, 1917. E. S. Bastin made a more extended trip to the region during May and June, 1916, and his notes have been consulted in the preparation of the following descriptions. The mines are described in alphabetical order for each county.

Clay County.

The graphite area of Clay County, as shown on the maps accompanying articles by Prouty,* extended in an irregular belt from the extreme northeast corner of the county southwestward to a line drawn from Coleta to Millerville, a total length of about 27 miles. The maximum width does not exceed 4 miles. At present development is confined to the portion of this belt in the vicinity of Ashland and Lineville, and the producing mines are in the southern part of T. 19 S., R. 8 E., the northwestern part of T. 20 S., R. 8 E., the central and southwestern part of T. 20 S., R. 7 E., and the southeastern part of T. 20 S., R. 6 E. Ashland is the principal shipping point.

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*Prouty, W. F., Flake graphite in Alabama; its location, its history, and its value to the State; Birmingham Age-Herald, Jan. 28, 1917; Extent and development of flake graphite resources of Alabama; Manufacturers' Rec., Apr. 19, 1917, pp. 66-67.

The Acme Graphite Co. (office, Birmingham, Ala.) is building a large mill in the SE. ¼ sec. 16, T. 20 S., R. 7 E., about 5 miles west of Ashland. The strike of graphite schist is N. 40° E., the dip about vertical. The graphitic band shows a width of about 100 feet. On the northwest is hornblende schist and to the southeast quartz-mica schist containing a little graphite.

The Alabama Graphite Co. (office, Ashland, Ala.) has been a large producer since 1912. The old mill, in the NW. ¼ sec. 21, T. 20 S., R. 7 E., is of the usual type in the district and has a capacity of about 125 tons per 10-hour day. An electrostatic separator was formerly used in the finishing mill but has now been given up. There are several bands of graphitic schist near the mill. Work is at present confined to one of these which has a maximum width of about 60 feet. A new mill has been erected about 1¼ miles to the west of the old one. A wet concentration process is used here, and the concentrates are carried to the old mill for finishing. The graphitic schist near the new mill has been partly uncovered, but mining had not begun at the time of visit.

The American Graphite Co. (office, Ashland, Ala.) has a mill nearly completely in the SW. ¼ sec. 7, T. 20 S., R. 8 E., about 1½ miles north-northwest of Ashland. The proposed milling process departs from the usual practice, in that a series of rolls is substituted for the muller, with the object of breaking the flake as little as possible. Air separation is to be introduced between the rolls and the water flotation. The deposit is wide and shows coarsening of the flake near the small granite stringers.

The Axton Noe Graphite Co. (office, Ashland, Ala.) has a large mill nearly completed in the SE. ¼ sec. 17, T. 20 S., R. 7 E. The water-flotation separators being installed are of the circular type known as the Comer washer. Inclined screens will be used instead of bolting reels in the finishing mill.

The property of the Black Diamond Graphite Co. (office, Ashland, Ala.) is in the SE. ¼ sec. 24, T. 20 S., R. 6 E., about 7 miles west of Ashland.

The Central Graphite Co. (office, Ashland, Ala.) has recently been organized to work property in sec. 12, T. 20 S., R. 7 E., about 3 miles northwest of Ashland.

The mine and mill of the Clay County Graphite Co. are in the SW. ¼ sec. 8, T. 20 S., R. 8 E., about 2 miles north of Ashland, on the Ashland branch of the Atlanta, Birmingham & Atlantic Railway. The company has been a producer since March, 1916. The graphitic schist strikes northeast and dips about 25° SE. The mill is of the usual type, except that the muller is replaced by roughing and finishing rolls and the sands pass through a suction concentrator before water flotation. The finishing process is more elaborate than usual. The first step consists of air-blast concentration, followed by grinding in flour rolls and burr mills, with screening through a series of bolting reels. Besides the usual No. 1 and No. 2 flake and dust, a fourth product known as special dust and containing from 44 to 55 per cent carbon is also made.

The Crucible Flake Graphite Co. (office, Ashland, Ala.), formerly the Standard Graphite Co., has been a producer since November, 1916. Two large veins are now worked and others have been prospected. This is the only mine at which the unweathered rock is mined as well as the oxidized. It is said that this material is handled with little extra expense and gives a satisfactory concentrate. The flow sheet of the mill differs only slightly from that outlined on page 50. From the second dried the concentrates pass to blast fans, the sands from which are returned to the fine rolls, and pass again through the water-flotation separators. The mine is in sec. 30, T. 20 S., R. 6 E.

The Eagle Graphite Co. (office, Ashland, Ala.) has a mill nearly completed in the NE. ¼ sec. 30, T. 20 S., R. 7 E., about 7 miles west of Ashland. The graphite-bearing schist here strikes N. 50° W., dips 50° SE., and contains a considerable amount of large flake. On the footwall, now being cut to develop the deposit, is hornblende schist with garnetiferous streaks. The mill is expected to have a daily capacity of 150 tons. Roughing and finishing rolls will be used instead of the muller, and the sands will pass through an air concentrator before reaching the water-flotation machines.

The Empire Graphite Co. (office, Ashland, Ala.) owns property in secs. 31 and 32, T. 20 S., R. 7 E., about 6½ miles west-southwest of Ashland.

The property of the Great Southern Graphite Co. (office, Birmingham, Ala.) lies in sec. 14, T. 19 S., R. 8 E., about 8 miles north-northeast of Ashland, and is the easternmost of the Clay County mines. The plans for the mill have been completed and work is proceeding on the ground. It is expected that the mill will be in operation in June or July, 1917.

The mill of the Greismer Co. (office, Ashland, Ala.) is in the NE. ¼ sec. 21, T. 20 S., R. 7 E., about 4 miles west of Ashland; and the company owns a large area in secs. 15, 16, 21, and 22 of the same township. There are said to be six workable brands of graphitic schist from 50 to 100 feet wide on the property. Operations will at first be confined to a band of schist that crops out on the top of a high ridge about 1,000 feet south of the mill, and the ore will be brought to the mill by gravity tram. The strike of the schist is here about N. 75° E. and the dip is 65° SE. The mill is one of the largest in the district and is expected to have a capacity of 400 tons of ore in 24 hours. The crushing is to be done by a series of rolls and air separators will be employed before and after water flotation. In the finishing mill inclined screens will take the place of bolting reels.

The Jennings Graphite Co. (office, Ashland, Ala.) has been a producer since December, 1914. The old mill is in the NE. ¼ sec. 8, T. 20 S., R. 8 E., 2½ miles north-northeast of Ashland. A second mill, a short distance to the east, in the NW. ¼ sec. 9, is nearly completed. The band of graphitic schist worked at the old mill is from 50 to 100 feet in width, has a strike of about N. 60° E., and dips 45° SE. A band of micaceous material in the center is avoided in mining. At the new mill a rather narrower but apparently higher-grade body will be mined. The milling process is similar to that of neighboring mills except that electrostatic separation is introduced as a preliminary step in the finishing process. The new mill will be equipped only for concentration, and the concentrates will be finished in the finishing mill of the old plant.

The King Graphite Co. (office, Lineville, Ala.) has cleared ground for a 200-ton mill in the SE. ¼ sec. 6, T. 20 S., R. 8 E., 2½ miles north of Ashland. It is expected that the company will begin operations by September, 1917. A 50-foot band of graphite schist has been exposed by trenches. The schist strikes northeast and dips 45° SE.

The mill of the Lineville Graphite Co. (office, Lineville, Ala.), in the SW. ¼ sec. 22, T. 19 S., R. 8 E., 6 miles north-northeast of Ashland, has been in operation since the middle of March, 1917. A series of rolls take the place of the muller used in the older mills and the water-flotation machines are of the circular type. The waste products from the finishing process are returned to the water-flotation machines.

The May Brothers Graphite Co. (office, Ashland, Ala.) has a mill under construction in the SW. ¼ sec. 16, T. 20 S., R. 7 E. It is expected that operations will begin by September, 1917.

The Monitor Graphite Co. (office, Ashland, Ala.) is beginning the construction of a large mill in the NW. ¼ sec. 8, T. 20 S., R. 8 E., 2½ miles north of Ashland. The graphitic schist, which has been exposed on the hill above the mill, strikes N. 70° E., and dips 50° SE. The ore grades off into lean material on each side, but it is expected to give a workable thickness of about 100 feet.

The property of the National Graphite Co. (office, Ashland, Ala.) lies in the N. W.¼ sec. 13 and the SW. ¼ sec. 12, T. 20 S., R. 8 E., about 2 miles northwest of Ashland. The mill is nearly completed.

The mill of the Peerless Flake Graphite Co. (office, Lineville, Ala.) is nearly ready for operation. The property of the company lies in the NE. ¼ sec. 33 and the NW. ¼ sec. 34, T. 19 S., R. 7 E., nearly 5 miles north-northeast of Ashland.

The Quenelda Graphite Co. (office, Ashland, Ala.) owns large tracts of land in the western part of the district and has been a producer since 1913. The mill is in the SW. ¼ sec. 17, T. 20 S., R. 8 E., about 6 miles west of Ashland. The mine is about 2,000 feet southeast of the mill and the ore is hauled to the mill by steam locomotives. Two bands of schist striking about N. 60° E. and having a vertical dip are being mined. They average about 100 feet and 40 feet in width. In the center of the larger band, a lenticular horse of granite about 20 feet wide and 100 feet long has been left standing.

The mill follows the usual practice, except that a double cooling bin takes the crushed ore from the drier and is drawn on alternate days. In addition to 24 flotation machines of the usual type one circular machine is being tried. Air separation is not used except just prior to finishing, where a small electric fan takes out part of the sand.

The Southern Graphite Co. (office, Ashland, Ala.) began producing in 1916. The mill and mine are in the SW. ¼ sec. 13, T. 20 S., R. 7 E., 2 miles west-northwest of Ashland. The band of graphitic schist now being mined has a workable width of about 60 feet. The strike is northeast and the dip about 40° SE. A smaller band on the hanging-wall side was mined to some extent in the course of the preliminary operations. The average graphite content of the ore is said to be about 3 per cent, though several analyses showed material from 4 to 4.1 per cent. Two other schist bands, as yet unworked, have been prospected. The milling system is the same as elsewhere in the district and consists of jaw crusher, muller, rotary drier, water flotation, cylindrical drier, air separator, and finishing burr-mills and bolting reels.

The Southern Star Graphite Co. (office, Ashland, Ala.) is constructing a mill in the SE. ¼ sec. 16, T. 20 S., R. 7 E., 4½ miles west of Ashland. It is expected that operations will begin by June, 1917. The mill will be of the usual type and consist of jaw crushed, muller, rotary drier, cooling bin, water flotation, drying floor, air separator, and finishing mill. The graphite schist is here about 90 feet in width.

Besides the mines mentioned above there are several other companies planning to begin operations in the near future. Among these are the C. B. Allen Graphite Co., the Birmingham Graphite Co., the Black Diamond Graphite Co. (property in sec. 24, T. 20 S., R. 6 E. and sec. 19, T. 20 S., R. 7 E.), the Consolidated Graphite Co., the Dixie Graphite Development & Mining Co., the Graphite Development & Mining Co., the

Graphite Development Co., the Hood Graves Co., the Norway Graphite Co. (property in sec. 22, T. 20 S., R. 6 E.), and the Superior Flake Graphite Co. (property in secs. 15, 21, and 22, T. 19 S., R. 8 E.).

Coosa County.

The graphite-bearing belt of Coosa County extends from Goodwater southwestward to Coosa River. It is only in the Goodwater region, however, that active work is in progress. No production was made from this district during 1916, but in April, 1917, one company had a mill in full operation, another was building its mill, and three more contemplated beginning construction within a short time.

The Ceylon Co. (office, Birmingham, Ala.) has erected a large mill in the NE. ¼ sec. 16, T. 24 W., R. 19 E. A special process is used, the details of which are not made public. The graphite-bearing schist is said to average about 150 feet in width and has been prospected for 1,000 feet along the strike. The strike is about N. 35° E. and the dip is 55°-60° SE. The outcrop follows the crest of a prominent ridge, on the north side of which the mill has been built. An open cut is being carried across the deposit to the level of the ore bin, and it is planned to work back from this toward the mill, thus gaining the advantage of working against the dip. The ore grades off on the walls into leaner quartz schist containing small bands of graphitic schist. The graphite is shipped from Hollins, a station on the Central of Georgia Railway about 7 miles west of Goodwater.

The Goodwater Graphite Co. (office, Goodwater, Ala.) is erecting a mill about 1½ miles northwest of Goodwater and expects to be ready for operation by June 1, 1917. The ore will be crushed by a series of jaw crushers and rolls and circular water-flotation machines will be used for concentration. The graphite-bearing schist, which has a width of about 40 feet, strikes N. 70° E. and dips about 25° SE.

The Graphite Co. of America (office, Birmingham, Ala.) is planning to develop a large area of about 2 miles northwest of Goodwater, between the property of the Goodwater Graphite Co. and the Hatchet Creek. Graphite-bearing schist has been exposed in several pits and trenches. The strike is about N. 70°

E. and the dip averages 45° SE. It is planned to use a dry process in the mill.

The Royal Graphite Co. and the United Graphite Co. are also prospecting lands in the vicinity of Goodwater.

Chilton County.

The only plant in operation in Chilton County is the Flaketown Graphite Co., about 3½ miles northeast of Mountain Creek station on the Louisville & Nashville Railroad. The property was visited by Mr. Bastin in May, 1916, and will be described at length in the forthcoming bulletin on graphite deposits of the United States. A special process is employed at the mill, the details of which are not made public.

FUTURE OF THE ALABAMA GRAPHITE INDUSTRY.

The large number of new companies beginning operations at the present time naturally makes it of importance to consider the probable effect of the future increased production upon the market. If all the mills in the Alabama field are able to operate at anything like their expected capacity, the result will be an annual production of flake graphite of approximately 30,000,000 pounds, about 15 times the production of Alabama in 1913, and nearly equal to the entire importation from Ceylon for that year. As long as the war continues a largely increased production can probably be absorbed by crucible makers and other users of crystalline graphite, but if the graphite from Ceylon and Madagascar continues to enter the market freely, the price of domestic graphite will necessarily be reduced with the increase in production. On the other hand, mining conditions in Alabama are very favorable, the mining costs are low, and new developments in concentration and finishing will probably result in a larger percentage of good flake in the finished product and a higher saving of graphite of all grades. Costs of mining and milling at an efficiently managed plant should not exceed $50 a ton of concentrates produced, or about 2½ cents a pound for the finished product, and even with prices as low as 5 cents a pound for No. 1 flake, 3 cents for No. 2, and 1½ cents for dust, there should still be a possibility of profit. A recent article by Prouty* contains an interesting discussion of costs of production of graphite in Alabama. It is of course idle to speculate on the possible duration of present conditions, and the situation may be summed up by saying that as long as the present demand for crucibles in the manufacture of munitions continues, the plants in operation should all be able to make profits, and even with the expected drop in prices after the war the most favorably situated and efficiently managed plants should continue to be profitable.

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*Prouty, W. F., Extent and development of flake graphite resources of Alabama; Manufacturers' Rec., Apr. 19, 1917, pp. 66-67.

With a return of peace, however, operators will face an unfavorable condition caused by a decreased market and large increase in production.

IRON ORE.

ERNEST F. BURCHARD.

EUGENE A. SMITH.

ESSENTIAL FEATURES OF AN IRON-ORE DEPOSIT.

THE war in Europe has greatly stimulated prospecting for minerals and ores in the United States, and as a result of this prospecting many specimens are sent to the United States Geological Survey for identification. The majority of specimens are readily identified at sight; some require a brief visual examination; others require more elaborate physical or chemical tests. The Survey is not permitted to make chemical analyses or assays of minerals or ores for private persons or corporations, but it is compatible with the duties of the Survey to inspect a specimen and to state, if possible, what it is; to give an offhand opinion as to whether or not the material constitutes an ore; and to recommend or discourage further expense in prospecting it or in having analyses or assays made.

Iron minerals are among the most common and are abundantly distributed, and naturally many specimens are received by the Geological Survey. It is therefore believed that a few notes on these minerals and on the requirements of a deposit in order to render it of commercial importance may be of interest to those making inquiries on the subject. The classes of iron minerals that constitute a source of iron ore are oxides and carbonates. There are three general varieties of oxides, viz, hematite, brown ore, and magnetite. Brief descriptions of each follow.

SOURCE OF IRON.

The forms in which iron occurs in the earth in combination with other substances are very numerous. Nearly all hard rocks, as well as the softer soils, sands, clays, and many "mineral" waters contain iron in some combination and in varied proportions. Iron is seldom found "native"—that is, occurring in the earth in the form of metallic iron. When it is found in the metallic state, as, for instance, in meteorites that have fallen from space upon the earth, it is not in quantities large enough to be of commercial value. The combination of iron with one or more other substances is called an iron compound, or iron mineral, and where the iron compounds are such that iron can easily be extracted from them and they occur in such abundance that they can be mined profitably these iron compounds are called iron ores.

Iron in combination with other substances is regarded next to aluminum, a metal contained in clay, as the most abundant metal. Thus, according to recent calculations,* metallic iron forms about 4.50 per cent of the rock crust of the earth, compared with 7.85 per cent for aluminum.

IRON ORE.

There are four important types of ores of iron—red iron ore, or hematite; brown ore, or limonite; magnetic ore, or magnetite; and carbonate ore, or siderite—although there are hundreds of minerals in which iron is a constituent. These types of ore may easily be remembered through their most common colors, which are, respectively, red, brown, black and grayish.

Hematite.

Hematite includes all varieties of the anhydrous sesquioxide (Fe_2O_3). This is known locally as red hematite, specular ore, gray ore, fossil ore, oolitic ore, etc. Hematite is composed of two parts of the metal iron united with three parts of oxygen. Iron forms 70 per cent by weight of pure hematite and oxygen 30 per cent, and the mineral is known chemically as the sexquioxide of iron or ferric-oxide. Hematite may occur as a rock in beds, in veins, or in masses of irregular shape, and it may occur in a soft, earthy state, or as a loose debris in the soil, and yet in all these forms be profitably mined if the controlling conditions are favorable. Hematite is easily recognized in the hand specimen by its colors (red to steel-gray and black) and the red mark or streak it leaves when drawn across a rough surface and by its high specific gravity or superior weight as compared with the weight of pieces of ordinary red rock or red clay of equal size. The old-fashioned "keel" or red chalkstone formerly used by carpenters for marking lumber is a form of hematite. Finely ground hematite is used in the manufacture of red paint and other red coloring materials.

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*Clarke, F. W., The data of geochemistry, 3d ed.; U. S. Geol. Survey Bull. 616, p. 34, 1916.

Hematite is by far the most important iron ore. It is found in great abundance in the United States in the vicinity of Lake Superior in Minnesota, Michigan, and Wisconsin; in central New York; in the Appalachian region of Alabama, Georgia, Tennessee, and Virginia; and in eastern Wyoming. It also occurs in lesser quantities in Pennsylvania, Maryland, Kentucky, eastern Wisconsin, Utah, and California. (E. F. B.)

All the ore of this quality mined in Alabama occurs in the Clinton or Red Mountain formation. The Red Mountain ridges occur on each side of the anticlinal valleys which separate the coal fields. In places the red ore ridges are lacking on one side, usually the western, of the valleys, being cut out by faults, while on the other hand the ridge may be duplicated on one side of the valley by the same faults.

In most of the valley occurrences the moderate dips of the ore bed are on the eastern side and there are also practically all of the ore mines. Murphree's Valley makes an exception to this, the moderate dips and the iron mines being on the western side. The iron ore occurs mainly in the central part of the formation in seams or beds one to five in number, which vary in thickness from a few inches to thirty feet.

While the ore seams are very persistent along the outcrop which in Alabama must be as much as 50 miles, yet they vary greatly from place to place, being either too thin or too lean for profitable working in the greater part of this distance.

The most important development of the Clinton ore in this State and in the world is along the 15 or 16 miles stretch of the east Red Mountain between Birmingham and Bessemer, and there is a practically continuous series of mines and strippings for this entire distance. Much mining of this ore has also been done near Gate City, Village Springs, Attalla, Gadsden, Round Mountain, Gaylesville, Fort Payne, Valley Head, etc.

The completion in October, 1912, of a diamond drill boring in Shades Valley, within a mile of the base of Shades Mountain, gives a definite answer to the speculations concerning the occurrence of red ore under Shades Valley. This boring shows that there is no falling off in the thickness and quality of the ore with distance from the outcrop, and that the depth of the ore below the surface at a distance of more than 2½ miles from the outcrop on Red Mountain is not too great for shaft mining.

The importance of this demonstration of a vast increase in the amount of red ore available immediately or in the near future, cannot well be overestimated.

In 1913 the Gulf States Steel Company acquired about 1,500 acres of land upon which the drill hole above mentioned was located. They have since sunk a double track slope to the ore. In time this is likely to be the largest producing mine in the State.

Another drill hole was put down in Shades Valley in 1913, in Section 19, T. 19, R. 3 W., but the record was not available for publication at the present time.

The hematite production in Alabama in 1916 was 5,672,005 long tons, as against 4,374,309 tons in 1915, an increase of 1,297,696 tons or 29.44 per cent. This 1916 production of hematite is 84.05 per cent of the total iron ore production of the State, and 7.55 per cent of the total iron ore production of the United States.

The average price of hematite in Alabama in 1915 was $1.25; in 1916, $1.52. (E. A. S.)

Brown Ore.

Brown ore is composed of iron, oxygen, and water, and in a general way might be said to be hematite combined with water. A general formula may be expressed by $nFe_2O_3nH_2O$. Brown ore may contain water in several proportions so that the percentage of iron likewise varies, but the latter ranges generally from 52 to 66 per cent in the pure mineral. Thus brown ore does not contain quite as high a percentage of iron as hematite, and therefore it can not yield so much metal. One of the most common brown ore minerals is known as limonite ($2Fe_2O_3 . 3H_2O$), and this contains 59.9 per cent of iron, 25.7 per cent of oxygen, and14.4 per cent of water. Brown ore occurs in a large variety of forms, nearly all of which have in common a characteristically yellowish-brown to chocolate-brown color and yield a brown streak and powder. Exceptionally certain hydrated sesquioxides of iron may appear bright red, and some may show black surfaces; but these exceptional forms are generally to be found closely associated with a mass of ordinary brown ore, and familiarity with the deposits soon dispels any perplexity regarding the nature of the ore on the part of persons mining or handling it. The specific gravity of brown ore is also higher than that of ordinary rock. Brown ore commonly occurs in irregular masses and lumps, and as ore gravel and sand, embedded in banks of clay, sand, and stone gravel. The ore in places lies in layers, but more commonly in irregular pockets, separated by barren clay, sand, and stone gravel. In places the ore takes the form of hollow concretions or "pots" which may contain some loose sand or clay in the interior, and also it appears as honeycombed masses ramifying through the inclosing ore-bearing ground.

Limonite is used chiefly as a source of iron, but the brown and yellow forms, called ocher, are used for paint and for making oil-cloth and linoleum. A porous variety of limonite is used in the purification of illuminating gas, and also as a contact material in the production of hydrogen gas for inflation of dirigible balloons and for precipitation of fats from oils. Many iron compounds are used in medicines.

Deposits of brown iron ore are common in many portions of the eastern United States, particularly in valleys underlain by limestone. Some of the best-known deposits are in Connecticut, Vermont, Pennsylvania, Virginia, Tennessee, Alabama, northeastern Texas, and in Iowa and Wisconsin near Mississippi River. (E. F. B.)

This ore, the second in importance in the State, and third in the United States, furnishes only 1.43 per cent of the total iron ore production of the United States, and 15.94 per cent of the iron ore production of the State in 1916. The entire brown ore production of the United States in 1916 was 1,904,484 long tons of which Alabama contributed 1,075,896 tons or 56.49 per cent, and the State holds accordingly the first rank in this industry.

In the early days of iron making and up to the year 1876 this was the only ore used in the catalan forges, bloomaries, and charcoal furnaces of the State. It was then demonstrated that good iron could be made at low cost from the red ores, with coke for the fuel.

In general the limonites are considered the best of the ores of Alabama and they command the highest prices and command a ready sale.

The usual mode of occurrence is in irregular masses of concretionary origin in the residual clays resulting from the decomposition of limestones, and as a consequence the mining is uncertain and expensive. Limonite also occurs in regularly stratified seams or beds, and then it is the result of the alteration of pyrites or of carbonate ores. Practically all of the brown ore actually mined is that occurring in the residual clays above mentioned. Most of the ore before going to the furnace is washed and screened, and this manipulation, together with the cost of mining, makes it the most expensive of the iron ores, and it is therefore seldom used alone, but is usually mixed with the red ore in proportions determined by the quality of the iron desired. It is used alone in the charcoal furnaces and also in the coke furnaces when a particularly tough pig iron is wanted.

The limonite deposits are very numerous and are distributed over a broad expanse of country and in many places are known to be very extensive. In some of the deposits the ore is in nearly solid mass, in others it is much scattered, and in consequence the amount of foreign material necessary to be moved for every ton of ore produced, varies very much, not only in the different ore banks, but also in the different parts of the same bank.

The deposits occur in nearly all the geological formations of the State, but in most of these the ore is either insufficient in quantity or not pure enough to be of much commercial value. The most important of the deposits, in point of extent and value, occur overlying the following formations, viz., the Knox Dolomite and the Weisner Quartzite, the Lauderdale Chert of the Lower Carboniferous, and the Lafayette. Some extensive beds of ore of inferior quality generally occur also in the Tuscaloosa formation of the Cretaceous, and in the upper part of the Lower Carboniferous and in the Metamorphic rocks.

The limonite or brown ore production of Alabama in 1916 was 1,075,896 long tons as against 935,045 tons in 1915, an increase of 140,851 tons or 15.06 per cent.

The average price per long ton of brown ore marketed in Alabama in 1916 was $1.97, as against $1.68 in 1915. (E. A. S.)

Magnetite.

Magnetite (Fe_3O_4) is a black ore of iron which is attracted by the magnet. It contains iron and oxygen in the proportion of 3 parts of iron to 4 parts of oxygen, which by weight gives 72.4 per cent of iron and 27.6 per cent of oxygen. Magnetite thus contains the highest percentage of iron of the ores thus far mentioned, and in fact, of all the iron ores. Magnetite usually occurs in granular form and in crystals in veins in comparatively old crystalline rocks, although it may be found in comparatively young volcanic rock.

Magnetite is found in the United States in considerable quantities in the Adirondack region of New York, the Highlands of New Jersey, south Pennsylvania, eastern Wyoming, central Texas, southwestern Utah, and southern and northern California, and in small quantities in northern Michigan and in other States. It is used chiefly for the production if iron, but the less common variety known as lodestone, which is naturally magnetic, is sold at high prices for museum exhibits and for laboratory purposes. Magnetite is found in the form of sand along streams and on the shores of lakes or seas where it has been concentrated by the action of water. In this form it has not proved of much commercial value as an ore of iron. (E. F. B.)

There has been no development of magnetic ore properly speaking, in Alabama. The gray ore of Talladega county which was mined to some extent a few years ago is essentially a hematite though some of it is slightly magnetic. There was no production of this ore in 1916. (E. A. S.)

Siderite.

Siderite, or iron carbonate ($FeCO_3$), is composed of 1 part of iron, 1 part of carbon, and 3 parts of oxygen and thus contains by weight where pure, approximately 48.3 per cent of iron, 10.3 per cent of carbon, and 41.4 per cent of oxygen. Iron carbonate ore where fresh is generally grayish in color, and occurs in nodules and in layers principally in sedimentary rocks that contain coal and lignite. The carbonate rapidly changes to brown ore on exposure to moist air. Siderite is known locally as spathic iron ore, kidney ore, clay ironstone, and blackband ore. Certain of these names are derived from the appearance of the ore in its different forms. For instance, a bed of carbonate ore that is found on the top of a coal bed in eastern Kentucky is striped with fine black carbonaceous bands.

Iron carbonate, in addition to being found in Kentucky, is common in southeastern Ohio, and occurs to a small extent in Pennsylvania, Alabama, Mississippi, and Texas.

IMPURITIES IN IRON ORE.

Consideration should be given to some of the principal impurities that are found in iron ores, first, in order to appreciate why a deposit of ore never yields the full percentage of iron that the predominant iron mineral contains, and, second, in order to show the relation of the ore to the operation of the blast furnace. Deposits of iron ore are generally so closely associated with the rocks which inclose them that they contain either mixed with the deposit or chemically combined within it some of the other rock-forming minerals. Among the most common of these minerals are silica, or sand; lime and magnesia, derived from limestone and dolomite; alumina, a clay mineral; manganese, a metal resembling iron; and small quantities of sulphur and phosphorus. The presence of varying percentages of these and other minerals tends, of course, to reduce the percentage of metallic iron that the deposit will yield when mined, and they must be removed as far as possible in mining and almost completely in the process of making iron. Therefore, it is of the utmost importance that the average chemical composition of a deposit of iron ore be ascertained before an attempt is made to mine it.

The average composition may be termed the "quality" of the deposit. The quality is determined chiefly by two men, the prospector and the chemist. The prospector digs trenches and pits or drills holes in the ore and takes samples of it. The chemist analyzes these samples of ore in his laboratory, and finds the percentages of metallic iron, silica, lime, alumina, manganese, sulphur, phosphorus, water, etc., contained in average samples of the ore. On the quality of the ore depend the quantity of fluxing stone and fuel that must be used in the blast furnace and the kind of iron that can be produced.

RANGE IN COMPOSITION.

Many chemical analyses of commercial grades of these iron ores indicate a range in composition given in the following table:

Range in chemical composition of commercial grades of iron ore.

	Hematite Per cent	Brown ore Per cent	Magnetite Per cent	Carbonate Per cent
Metallic iron	25-65	35-58	48-70	25-48
Silica	2-35	3-23	0.6-20	1-23
Alumina	0.2-9	1.4-12	0.7-4.5	1-5
Lime	Trace to 27	0-0.6	0.5-4.5	0-7
Manganese	Trace to 5	0.16-5	0.07-1.5	0.1-4.7
Sulphur	Trace to 1.5	Trace to 0.5	Trace to 1.2	0.01-1.8
Phosphorus	0.013-1.23	0.04-1	Trace to 1.75	0.043-0.7
Titanium	0-0.9	....	0-1.5	0-0.04
Water	0.3-6	3.3-15	0.25-0.5	0-6.5

Under exceptional conditions ores are mined that contain more or less of the common constituents indicated above, but local conditions may determine whether an ore that falls within the limits shown may be mined. For instance, hematite carrying as little as 2 per cent metallic iron would not be considered of value as an ore unless it contained enough lime to flux the silica and alumina present. Most southern red hematites contain considerable quantities of lime and are therefore workable where a highly siliceous ore carrying no more metallic iron and little lime would not be available under present conditions of metallurgic practice. At present ores averaging less than 25 per cent of metallic iron are not charged into blast furnaces in any considerable quantities, and ores as lean as this can not be used economically unless they carry more than enough lime to flux them and are used in connection with richer ore. In using limestone as a flux it would probably be more desirable to use a stone carrying 15 to 20 per cent of ferric oxide (10.5 to 14 per cent metallic iron) than one containing only 3 to 5 per cent ferric oxide, on account of the higher iron yield of the former. Nevertheless, the more ferruginous limestone would not commercially be classed as an ore; yet a bed carrying 35.5 per cent ferric oxide (25 per cent metallic iron), although in itself not quite rich enough, might be conceded to be an "ore." There are other exceptions to be noted in this table. Some deposits of nontitaniferous magnetite can be so treated by means of crushing and electromagnetic separation that, although they may contain as little as 25 per cent metallic iron, they will yield a high grade concentrate. Such ores may be used to advantage, especially where they can be concentrated along with richer grades. Considerable phosphorus is present in the mineral apatite associated with Adirondack magnetite; and this and silica are largely eliminated by electromagnetic concentration. The possibilities of various methods of concentration or beneficiation must therefore be taken into consideration in appraising an ore, and this involves consideration of the physical as well as the chemical character of the ore. The content of water is a widely variable item. Some ores contain much absorbed water, which can be driven off by drying. Hematite is found in all stages of hydration, and thus may contain water up to the point where it should really be classed as a brown ore. Hydrated ores are thus concentrated by heating to drive off the chemically combined water. Carbonate ores are calcined to drive off both carbon dioxide and water. Some iron oxides are subjected to a partial reduction and are thus rendered magnetic, and the separation of nonmetallic impurities is thereby greatly facilitated. One brown-ore deposit that averages in the raw state not more than 30 per cent of metallic iron is thus through a complicated process of beneficiation rendered of commercial value. The question of beneficiation is therefore becoming increasingly important; and there must also be taken into consideration the proximity to transportation, and to blast furnaces, to water-power sites for possible electric reduction, as well as the prevailing conditions of the market. The laws of supply and demand that prevail in 1917 make available lower grades of ore than would be considered desirable in times when low prices for iron and steel are current. The question of quantity available is also of importance, for iron ore is so bulky a product, is relatively so low in value even at the best, and involves so large an expenditure for equipment for mining on a satisfactory scale that any deposit should contain several years' supply to be worthy of development.

To summarize, then, the ore should occur in a deposit containing several hundred thousand tons of merchantable grade, susceptible of economical mining and convenient to transportation and markets, if its development is to be seriously considered. (E. F. B.)

Details of Iron Ore Production In Alabama, 1915-1916.

The following tables show details concerning the production of iron ore in the State, together with the rank of the State in mined and marketed iron ore in 1915 and 1916:

Iron ore mined in Alabama, 1915-1916, by varieties, with percentage of increase in 1916 in long tons.

YEAR	Hematite	Brown ore	Total Quantity	Percentage of total U. S. Produc'n.
1915	4,374,309	935,045	5,309,354	9.74
1916	5,672,005	1,075,896	6,747,901	8.99
Increase	1,297,696	140,851	1,438,547	....
Percentage	29.44	15.06	27.09	....

Iron ore shipped from Alabama mines, 1915-1916.

YEAR	Quantity (Gross tons)	Value
1915	5,134,955	$6,798,266
1916	6,801,839	10,843,231
Increase	1,666,884	4,044,965
Percentage	32	59

Average price per gross ton of iron ore shipped from mines in Alabama and the United States, 1915-1916.

	HEMATITE		BROWN ORE	
	1915	1916	1915	1916
Alabama	$1.25	$1.52	$1.68	$1.97
United States	1.80	2.32	1.80	2.03

General Average, 1915—$1.83; 1916—$2.34.

Rank of the first five states in mined and marketed production of iron ore in 1915 and 1916.

1915

Rank	STATE	MINED		MARKETED			
		Quantity (long tons)	Percentage of total product'n	Quantity (long tons)	Percentage of total product'n	Value	Percentage of total value
1	Minnesota	33,464,660	60.27	32,545,236	58.63	$57,742,643	57.01
2	Michigan	12,514,516	22.54	13,664,437	24.63	28,218,627	27.86
3	Alabama	5,309,354	9.74	5,134,955	9.76	6,798,266	6.71
4	Wisconsin	1,095,388	1.97	1,125,269	2.03	2,188,012	2.16
5	New York	998,845	1.79	931,745	1.68	2,797,270	2.76

1916

Rank	STATE	MINED		MARKETED			
		Quantity (long tons)	Percentage of total product'n	Quantity (long tons)	Percentage of total product'n	Value	Percentage of total value
1	Minnesota	44,585,422	59.31	45,869,251	58.91	$106,628,784	58.62
2	Michigan	18,071,016	24.04	18,995,797	24.27	49,054,340	26.97
3	Alabama	6,747,901	8.99	6,801,839	8.61	10,843,231	5.96
4	New York	1,342,507	1.78	1,464,917	1.88	5,571,429	3.06
5	Wisconsin	1,304,518	1.72	1,529,459	1.96	3,644,542	2.00

PRINCIPAL IRON ORE MINES.

In 1916 there were 405 iron ore mines active in the United States, and 222 mines in 1916 produced more than 50,000 gross tons of iron ore each, compared with 184 mines in 1915. Of these 222 mines, 12 produced more than 1,000,000 tons of iron ore each in 1915, 5 more than in 1915. First place in 1916 was held by the Hull-Rust mine at Hibbing, Minn.; second place by Red Mountain group near Bessemer, Ala. The production of the Alabama mines producing more than 50,000 gross tons each in 1916 is given below in tabular form.

Ion ore mines of Alabama that produced more than 50,000 long tons each in 1916.

Rank.	Name of Mine	Nearest Town	Variety of Ore	Quantity
1	Red Mountain Group	Bessemer	Hematite	2,809,588
2	Woodward, Nos. 1, 2 & 3	Lipscomb	Hematite	833,308
3	Songo	Songo	Hematite	248,958
4	Raimund No. 1	Bessemer	Hematite	241,564
5	Steinman	Steinman	Hematite	172,800
6	Greeley	Greeley	Brown Ore	151,927
7	Spaulding	Birmingham	Hematite	134,289
8	Attalla	Attalla	Hematite	117,456
9	Ironaton	Ironaton	Brown Ore	111,416
10	Raimund, No. 2	Bessemer	Hematite	86,965
11	Houston	Rickey	Brown Ore	79,307
12	Docray	Docray	Brown Ore	71,996
13	Raimund, No. 3	Bessemer	Hematite	68,295
14	Tannehill	Goethite	Brown Ore	65,997
15	Valley View, No. 2	Birmingham	Hematite	51,446

BENEFICIATED IRON ORE.

Statistics of beneficiated iron ore were gathered by the Survey for the first time during the canvass for the year 1914 and, although complete returns were not at first received from every producer who subjects his ore to any form of beneficiation, the responses to the special inquiries have been, on the whole, satisfactory and interesting, and they showed continued improvement in 1915 and 1916.

The following processes were reported as employed to improve the quality of the ore at various mines: Crushing and screening, drying by direct heat and by steam, hand picking on tables and on belts, washing by means of hydraulic jets and logs, jigging, electromagnetic cobbing, other concentration and separation, calcining, nodulizing, and desulphurization by sintering. Some of the operations combined two or more of these processes. Iron ores were reported as beneficiated at 83 mines in 14 States in 1916 and at 66 mines in 14 States in 1915, and in addition at the brown-ore mines of the Spanish-American Iron Co. in Cuba.

In Alabama the ore treated was red hematite and brown ore, and the usual processes to which it was subjected were log washing, screening, and picking belt. A total of 996,344 gross tons of beneficiated brown ore, valued at $1,969,706, was marketed from 12 mines in Alabama in 1916, compared with 744,193 tons, valued at $1,278,344, from 9 mines in 1915. Of this, 117,456 tons were hematite run over a picking belt. (E. F. B.)

PIG IRON.

PRODUCTION, SHIPMENTS, AND VALUE OF PIG IRON, BY STATES.

THE bureau of statistics of the American Iron & Steel Institute reports the production in 1916 of all kinds of pig iron, including such ferroalloys as spiegeleisen, ferromanganese, ferrosilicon, and ferrophosphorus, produced in blast furnaces as well as some that were electrically produced as 39,434,797 gross tons, compared with 29,916,213 tons produced in 1915, an increase of 9,518,584 tons, or 32 per cent.

The following table gives the total production of pig iron in 1915 and 1916, by States, according to their rank each year:

Pig iron, including some ferroalloys, manufactured in the United States in 1915 and 1916, in gross tons.*

STATE	1915	1916
Pennsylvania	12,790,668	16,506,284
Ohio	6,912,962	8,602,895
Illinois	2,447,220	3,922,512
New York	2,104,780	2,352,535
New Jersey		
Alabama	2,049,453	2,762,885
Indiana	1,986,778	2,221,708
Michigan		
Wisconsin	372,966	811,325
Minnesota		
West Virginia	291,040	554,590
Kentucky		
Missouri	271,921	437,633
Iowa†		
Colorado		
Washington		
California		
Maryland	251,548	501,452
Virginia	251,346	399,885
Tennessee	177,729	355,874
Connecticut	7,802	5,719
Massachuseetts		
	29,916,213	39,434,797

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*Bureau of Statistics of the American Iron & Steel Institute.

†Ferrosilicon produced in electric furnace for first time in 1916.

Pig iron shipped from blast furnaces in the United States in 1915 and 1916.

STATE	1915		1916		Increase in 1916		Percentage of increase in 1916.	
	Quantity (gross tons)	Value	Quantity (gross tons)	Value	Quantity (gross tons)	Value	Quantity	Value
Alabama	2,320,255	$28,757,124	2,672,498	$38,994,660	352,243	$15,237,536	15	64
Illinois	2,455,894	34,207,901	3,857,391	67,764,309	1,401,497	33,556,408	57	98
Kentucky	105,700	1,420,275	144,444	2,595,600	38,744	1,175,325	37	83
Michigan	486,106	6,624,559	505,646	8,851,361	19,540	2,226,802	4	34
New York	2,010,076	28,178,466	2,289,608	40,537,240	279,532	12,358,774	14	44
Ohio	6,995,000	90,549,626	8,689,030	136,855,228	1,694,030	46,305,602	24	51
Pennsylvania	12,779,974	174,926,891	16,351,131	293,437,782	3,571,157	118,510,891	28	68
Tennessee	208,298	2,519,337	329,342	4,981,538	121,044	2,462,201	58	98
Virginia	265,616	3,408,784	444,491	7,140,002	178,875	3,731,218	67	109
Wisconsin	302,913	3,997,940	423,973	7,534,327	121,060	3,536,387	40	88
Other States‡	2,454,654	31,818,701	3,418,770	54,786,071	964,116	22,967,370	39	72
	30,384,486	401,409,604	39,126,324	663,478,118	8,741,838	262,068,514	29	65

‡1915; Colorado, Connecticut, Indiana, Maryland, Massachusetts, Minnesota, Missouri, New Jersey, and West Virginia; 1916: California, Colorado, Connecticut, Indiana, Maryland, Massachusetts, Minnesota, Missouri, New Jersey, and West Virginia.

AVERAGE PRICES.

The average price per gross ton of all kinds of pig iron, by States, from 1911 to 1916, given in the following table is based on reports of the manufacturers to the Survey. These figures represent the prices at the blast furnaces and do not include the prices of ferroalloys.

The average prices for 1915 and 1916 appear low for such active years in the iron industry. Prices, however, did not revive as rapidly as production, and in the early months of the year orders were taken at low prices for delivery late in the year by many producers who did not clearly foresee the future possibilities. At the close of 1915 market prices of pig iron were 35 to 40 per cent above the average for that year and at the close of 1916 they were between 45 and 68 per cent higher than at the beginning of the year, but this increase was confined almost entirely to the last two or three months of the year, so that the average increase in price was only 28 per cent.

Average price per gross ton of pig iron in the United States, 1911 to 1916.

STATE	1911	1912	1913	1914	1915	1916
Alabama	$10.75	$10.75	$12.08	$10.52	$10.24	$14.59
Illinois	15.30	15.26	15.83	13.59	13.93	17.57
Kentucky	15.01	15.74	16.09	12.24	13.44	17.97
Michigan	15.34	14.30	14.69	13.78	13.63	17.51
New York	15.56	14.22	15.35	14.26	14.02	17.70
Ohio	13.68	13.07	15.02	13.46	12.96	15.75
Pennsylvania	14.23	14.60	15.36	13.78	13.69	17.95
Tennessee	11.56	12.29	13.22	12.05	12.09	15.13
Virginia	12.62	13.27	13.96	12.53	12.83	16.06
Wisconsin	15.51	14.33	15.13	13.35	13.20	17.77
Other States*	14.94	14.07	15.50	13.55	12.96	16.03
Average for United States	14.07	13.93	15.08	13.42	13.21	16.96

1911: California, Colorado, Connecticut, Georgia, Indiana, Maryland, Massachusetts, Minnesota, Missouri, New Jersey, and West Virginia; 1912 and 1913: California, Colorado, Connecticut, Indiana, Maryland, Massachusetts, Minnesota, Missouri, New Jersey, and West Virginia; 1914: California, Colorado, Connecticut, Indiana, Maryland, Massachusetts, Minnesota, Mississippi, Missouri, New Jersey and West Virginia; 1915: Colorado, Connecticut, Indiana, Maryland, Massachusetts, Minnesota, Missouri, New Jersey, and West Virginia; 1916: California, Colorado, Connecticut, Indiana, Maryland, Massachusetts, Minnesota, Missouri, New Jersey, and West Virginia.

BLAST FURNACES.

The number of furnaces in blast on June 30 and December 31 and the total number of stacks recorded for the years 1915 and 1916, not including any electric reduction furnaces, as published by the bureau of statistics of the American Iron and Steel Institute, are as follows:

Blast furnaces in the United States, 1915 and 1916.

STATE	Furnaces in blast June 30, 1915.	Dec. 31, 1915			Furnaces in blast June 30, 1916	Dec. 31, 1916		
		In.	Out.	Total.		In.	Out.	Total.
Pennsylvania	96	125	31	156	132	127	30	157
Ohio	50	62	12	74	67	65	12	77
Illinois	12	21	5	26	23	24	0	24
Alabama	20	27	20	47	31	29	18	47
New York	16	18	9	27	20	18	9	27
Virginia	5	7	15	22	9	9	13	22
Tennessee	5	6	12	18	12	11	7	18
Colorado	2	2	4	6	4	3	3	6
Iowa					0	0	0	0
Missouri	1	1	1	2	1	2	0	2
Oregon	0	0	1	1	0	0	1	1
Washington								
California	0	0	0	0	0	0	0	0
Maryland	2	3	2	5	4	4	1	5
New Jersey	1	1	4	5	1	1	4	5
Wisconsin	4	7	1	8	6	5	3	8
Minnesota	1	2	0	2	3	3	0	3
Indiana	10	10	0	10	10	10	0	10
Michigan	8	11	3	14	12	12	2	14
West Virginia	1	3	1	4	4	4	0	4
Kentucky	1	3	3	6	4	4	2	6
Georgia	0	0	4	4	0	0	4	4
Texas	0	0	2	2	0	0	2	2
Mississippi	0	0	1	1	0	0	1	1
Connecticut	1	1	2	3	0	1	2	3
Massachusetts	0	0	2	2	1	1	1	2
	236	310	135	445	344	333	115	448

Of the ferro-alloys used in the manufacture of steel only the ferro-manganese and spiegeleisen are manufactured in Alabama at two localities. In 1916 ferro-manganese was valued at $134.42 a long ton, and spiegeleisen at $33.68 a ton as against $64.14 and $20.98 a ton respectively for 1915. This great increase in value stimulated the search for deposits of manganese in the State, but production in very limited quantity by one company only has been reported for 1916 in the State.

STEEL.

The figures for the production of steel in Alabama in 1916 are not available for publication.

LIME.

DURING the year 1916 there was an increase in the production of lime in Alabama, as compared with the production of the preceding year. The total product of 9 plants in 1916 was 67,524 short tons, an increase from 1915 of 7,192 tons, or 11.92 per cent.

The value of the product was $312,531, an increase of $62,304 or 24.89 per cent.

The most important use of the lime produced was for building purposes, 11.32 per cent of the product is definitely so credited in the returns while the greater part of the lime sold to dealers and most of the hydrated lime go to building purposes. Other chief uses of lime are in chemical works, paper mills, tanneries, agriculture, manufactories of sand-lime brick, slag cement, etc.

Shelby County, as heretofore, was the largest producer in 1916, being credited with 52,809 tons or 78.21 per cent of the total. The other producing counties in the order of their importance are Blount and Jackson.

The following tables give some additional data on the lime production in Alabama in 1915 and 1916.

For a full account of the lime industry in the United States, those interested are referred to the article on Lime, by G. F. Loughlin, in "Mineral Resources of the United States, 1916."

Lime burned and sold in Alabama in 1915 and 1916.

YEAR	Rank of state by quantity	Quantity (short tons)	Value	Rank of state by value	Average price per ton	Number of plants in operation
1915	16	60,332	$250,227	17	$4.15	14
1916	16	67,524	312,531	23	4.63	9
Increase		7,192	62,304			
Percentage		11.92	24.89			

Lime sold in Alabama in 1915 and 1916, by uses.

	Quantity (short tons)	Value	Average price per ton U. S.
1915			
Building lime	13,177	$54,976	*$4.26
Chemical works	1,369	5,769	3.36
Paper mills	†	†	3.61
Sugar factories	801	3,368	6.77
Tanneries	†	†	4.06
Agriculture	379	1,308	*3.21
Dealers, uses not specified	40,081	169,600	4.22
Other uses and undistributed	4,575	15,206	....
Total	60,382	$250,227	....
Hydrated lime (included in total)	6,302	28,553	....
1916			
Building lime	7,744	$33,069	$5.21
Chemical works	703	2,571	3.70
Paper mills	†	†	4.14
Sugar factories	....	....	5.41
Tanneries	†	†	4.64
Agriculture	592	2,246	3.68
Dealers, uses not specified	50,007	243,582	4.95
Other uses, and undistributed	8,478	31,068	....
Total	67,524	$312,531	....
Percentage of increase in 1916	11.92	24.89	....
Hydrated lime (included in total)	6,780	36,864	....
Percentage of increase in hydrated lime in 1916	7.58	29.11	....

*Revised. †Included in "Other uses and undistributed."

MANGANESE.

THERE has been very little production of manganese during the past few years. Only one company has reported production in 1916 from near Walnut Grove in Etowah County. A second firm has reported some progress in development. Because of the great demand for manganese in the time of the war, thorough investigation should be made of some of the most promising localities. Among these localities worthy of further investigation are Murphree's Valley in Blount and Etowah, Shinbone Valley in Clay County, and many other localities in Etowah, St. Clair, Calhoun and Cleburne counties mentioned in the State Geological reports. In the Shinbone Valley along the eastern foot hills of the Talladega Mountain range, there is a practically continuous outcrop of manganese ore which can be followed up to the southern boundary of Cleburne County.

Many specimens of high-grade merchantable ore have been collected from these outcrops, but the prospecting has not yet shown that the quantity of such high-grade ore will justify the working on commercial scale.

MICA.

MICA mines were opened in Alabama during the early days of mica mining in the Southern States. Prospects have been tested at various subsequent times, and considerable mining has been carried on at intervals during the last twenty years.

The mines are located in Randolph, Cleburne, Clay and Tallapoosa counties, and there are prospects also in Lee, Coosa, and Chilton counties.

In 1916 there were six mines producing mica as against four in 1915. The output was 14,132 pounds of sheet mica, valued at $4,955, and a few hundred dollars worth of scrap mica.

The output of sheet mica in 1915 was 8,400 pounds valued at $5,545, showing an increase in 1916 of 5,732 pounds or 68.24 per cent, but a decrease in the value of $590.00 or over 10 per cent.

MINERAL WATERS.

By Arthur J. Ellis.

Character of Statistics.

THE statistics given in this report have been compiled from individual reports furnished by the owners or operators of springs and include, so far as can be ascertained, only natural waters that are bottled and sold in their natural state or only slightly altered from their natural state. Natural still waters that have been artificially carbonated, natural carbonated waters that have lost part of their carbon dioxide, and waters from which iron has been removed are included; but artificial waters and natural waters that have been flavored, concentrated, fortified, diluted, or otherwise essentially modified in chemical character are excluded if available information indicates such treatment. Water given away or consumed at spring resorts, which constitutes a large part of the annual production, is excluded. Waters sold at flat or meter rates, delivered to consumers through pipes, or otherwise obviously municipal supplies or adjuncts to them are excluded. This is the nearest practicable conformity with the commonly accepted definition of natural mineral water. No distinction is made between mineral water flowing or pumped from a natural spring and that flowing or pumped from a dug, bored, driven, or drilled well. Many of the best-known mineral waters in the United States come not from natural springs but from wells.

Distinction for statistical purposes between table and medicinal waters is entirely arbitrary. Most table waters are clear, sparkling, and without distinct mineral taste or odor; many medicinal waters are highly mineralized and have distinct mineral taste and odor. Yet some table waters are more strongly mineralized than some medicinal waters, and many medicinal waters contain less mineral matter than certain city supplies. The basis here used for distinguishing medicinal from table waters is the report regarding the spring, and this distinction is based in turn on the operator's knowledge that some of his customers buy the water to use regularly on their tables and others buy it for an aid during illness. A few strongly mineralized waters are not sold as table waters, and a few widely sold table waters are not used medicinally, but many waters are sold for both uses, though the reported sales of several medicinal waters have distinctly decreased in the last few years.

Mineral Water Trade in Alabama, 1916.

Returns from Alabama indicate that the mineral-water trade in 1916 was about 20 per cent more than that in 1915. The sales amounted to 103,944 gallons, and the value of the output was $12,174, the average price per gallon increasing from 10 cents to 12 cents. There was a considerable decrease in the value of the output of medicinal waters, but the large increase in the sales of table waters netted a gain of $3,262 in the total sales. Sixteen springs reported sales. One spring which was active in 1915 reported no sales for 1916. Gordon Mineral Springs is newly added to the list. Seven mineral-water bathing establishments and 5 resorts, accommodating about 800 guests, were maintained. The quantity of mineral water used in the manufacture of soft drinks increased from 2,300 gallons to 13,500 gallons.

The following 16 springs reported sales:

Bailey Springs, Florence, Lauderdale County.
Bladon Springs, Bladon Springs Choctaw County.
Blount Springs, Blount Springs, Choctaw County.
Bromberg Gulf Coast Lithia Spring, Bayou Labatre, Mobile County.
Cooks Springs, Cooks Springs, St. Clair County.
Dixie Spring, Dixie Spring, Walker County.
Gordon Mineral Springs, Canoe, Escambia County.
Healing Springs, Healing Springs, Washington County.
Livington Mineral Well, Livingston, Sumter County.
Luverne Mineral Spring, Luverne, Crenshaw County.
McCary Mineral Well, near Birmingham, Jefferson County.
Matchless Mineral Water Well, east of Greenville, Butler County.
Purity Spring, Spring Hill, Mobile County.
Shocco Springs, Talladega, Talladega County.
Talladega Springs, Talladega Springs, Talladega County.
White Sulphur Wells, near Jackson, Clarke County.

The following tables add some details to the general statements above given:

Mineral waters sold in Alabama in 1915 and 1916.

YEAR	Commercial Springs	Quantity Sold (gallons)	Average price per gallon (cents)	Value of medicinal waters	Value of table waters	Total value
1915	14	86,499	10	$8,213	$699	$8,912
1916	16	103,944	12	5,979	6,195	12,174

Comparative production of mineral waters in Alabama in 1915 and 1916.

YEAR	Commercial Springs	Quantity sold (gallons)	Value of product
1915	14	86,499	$8,912
1916	16	103,944	12,174
Increase	2	17,445	3,262
Percentage of increase	....	20	37

A comparison of American and European Mineral waters, by Alfred A. Chambers, is given in "Mineral Resources of the United States, Part II, pages 500-508." A discussion of the waters of Alabama, may be found in a report of the Geological Survey of Alabama, "Underground Waters of Alabama," by Eugene A. Smith, State Geologist, 1907.

NATURAL GAS.

By John D. Northrop.

IN 1916 natural gas in sufficient volume to supply the needs of 250 domestic consumers in Fayette, was obtained from four wells, one of which was completed during the year in the Fayette Gas Field, Fayette County, and enough for the needs of 85 domestic consumers in the town of Jasper, was obtained from two wells in Walker County.

Wild cat tests drilled in 1916 in quest of petroleum near Mobile, Mobile County, in southern Alabama, resulted in the discovery of numerous pockets of natural gas, but no commercial production of gas.

Nine wells in Madison County and one in Winston County in northern Alabama were reported closed in 1916.

Some details concerning the oil and gas situation in Alabama may be found in Bulletin 10 of the Geological Survey, Report on the Fayette Gas Field by M. J. Munn, and in Circular No. 3 Concerning Oil and Gas in Alabama, by Eugene A. Smith.

PETROLEUM.

By John D. Northrop.

NOTHING of consequence resulted from the quest for petroleum in Alabama in 1916. Late in December the discovery of oil in small quantities near Cordova, Walker County, furnished the basis for considerable local excitement, which, however, failed to result in the opening of a new field. So-called blow-outs near Mobile provided an incentive for drilling in that locality, and at the end of 1916 tests were under way west of that city.

SAND AND GRAVEL.

THE total production of sand and gravel in the State in 1916 was 726,650 short tons, valued at $184,216, as compared with 924,701 tons, valued at $242,336 in 1915, a decrease in the quantity of 198,051 tons, or 21.42 per cent, and a decrease in the value of $58,120, or 23.99 per cent.

There was an increase in the quantity of sand of 250,532 short tons, or 66.44 per cent, and in the value of $22,288, or 17.73 per cent. There was a great falling off in the quantity and value of the gravel, viz., a decrease of 448,583 tons, or 81.91 per cent in quantity, and of $80,408, or 68.91 per cent in value.

Railroad ballast, building and molding sands make 91.61 per cent of the sand production; railroad ballast 41.58, building 35.11 and molding sand 20.92 per cent, while the balance of 2.39 per cent represents the production of grinding and polishing, paving and other unclassified sands.

The following tables give a comparison of the production of sand and gravel in 1915 and 1916, and the production, value and kinds of sands in these two years.

Production in short tons of sand and gravel in Alabama in 1915 and 1916.

	SAND		GRAVEL		Total*		Percentage of U. S. total
	Quantity	Value	Quantity	Value	Quantity	Value	
1915	377,045	$125,664	547,656	$116,672	924,701	$242,336	1.05
1916	627,577	147,952	99,078	36,264	726,650	184,216	0.62
Increase or decrease	+250,532	+22,288	—448,583	—80,408	—198,051	—58,120	0.62
Percentage	+ 66.44	+ 17.73	— 81.91	— 68.91	— 21.42	— 23.99	....

*Chert has been added to these totals.

Quantity (short tons), value and kind of sand produced in Alabama in 1915 and 1916.

	Moulding Sand		Building Sand		Paving Sand		Engine Sand.		Grinding and Polishing Sand		Railroad Ballast Sand and Gravel		Other Sands		Total	
	Quantity	Value	Quantity	Value	Quantity	Value	Quantity	Value	Quantity	Value	Quantity	Value	Quantity	Value	Quantity	Value
1915	169,663	$59,862	157,581	$51,788	*	*	6,942	$1,779	*	*	*	*	7,294	$2,180	377,045	$125,664
1916	131,312	41,470	220,386	66,989	*	*	6,199	1,741	*	*	259,957	$32,413	*	*	627,577	147,952
Increase+ or Decrease—	—38,351	—18,392	*62,755	*15,201	....	....	— 743	— 38	....	....	....	....	....	....	+250,532	+22,288
Percentage	— 22.60	— 30.72	+ 39.82	+ 29.35	....	....	—10.70	—2.14	....	....	....	....	....	....	+ 66.44	+ 17.74

*Concealed because of less than three producers.

STONE.

EUGENE A. SMITH.

ON ACCOUNT of the variety of uses to which stone is put, there is no regular unit of measurement, and the figures in this report represent the values of the different varieties.

PRODUCTION.

Alabama produces only three kinds of stone, viz., limestone, marble and sandstone.

The total value of the stone produced in Alabama shows an increase in 1916 of 67.17 per cent. The greater part of this increase was in the limestone, (rough and dressed building stone, and furnace flux). There was a notable decrease in the sandstone, while the production of marble was practically the same as in 1915. Exact figures for marble, however, cannot be given as there were in 1915 as well as in 1916 only two producers.

The following table gives some additional details of the total stone production:

Total value of stone (limestone, sandstone and marble) produced in Alabama in 1915 and 1916. Percentage of total U. S. value, rank of State and number of plants.

Year	Total Value	Percentage of total U. S. value	Number of Plants	Rank of State
1915	$719,452	.96	25	28
1916	1,202,256	1.52	25	20
Increase in 1916	482,804			
Percentage	67.17			

LIMESTONE.

The most important use of limestone produced in Alabama in 1916 as in 1915, was for furnace flux, while building stone, both rough and dressed, follows next in importance. For the other uses given in the table the value of the limestone shows a decrease, notably in the case of the stone used in roadmaking.

The limestone burned into lime or used in the manufacture of Portland cement is not taken into account here, but is included in the value of each of the finished products in whose manufacture it was used.

As thus limited the total value of the limestone produced in 1916, was $917,559, as compared with $426,266 in 1915, an increase of $491,293 or 115.26 per cent.

The value of the limestone produced in Alabama in 1915 and 1916 classified according to the uses of the stone is given in the following table:

Value of limestone (not including marble) produced in Alabama in 1915 and 1916, according to uses.

USES	1915	1916	Increase or Decrease	Percentage
Rough building	$6,912	$18,067	+ $6,155	+ 89.19
Dressed building	15,487	29,597	+ 14,110	+ 91.11
Riprap	18,379	17,969	— 410	— 2.23
Crushed Stone:				
Road making	42,116	1,198	— 40,918	— 97.15
Railroad ballast	554	180	— 374	— 67.51
Concrete	45,443	41,321	— 4,122	— 9.03
Flux	289,167	807,344	+ 518,177	+ 179.19
Agricultural	7,386	4,656	— 2,730	— 36.96
Other	822	2,227	....	....
Total	$426,266	$917,559	+ 491,293	+ 115.26

LIMESTONE FOR BUILDING PURPOSES.

The preparation of cut stone for building purposes in Alabama, while on the increase, is not yet what it should be. Practically all of this material comes from the quarries in the subcarboniferous limestone of the Tennessee Valley, the most important quarries being at Rockwood in Franklin County, operated by Foster and Creighton Co., of Nashville. This stone is quite similar in appearance, composition, and other qualities to the Indiana stone, and so far as experience in the use of the stone from the two localities in the buildings of the

University of Alabama goes, the Alabama stone holds its own under influence of the weather better than does the Indiana stone. Stone steps, door sills, and window sills, buttress caps, etc., of the Alabama stone put in place in 1885 show practically no deterioration in color and wear under foot, and in crumbling and roughening under the influence of the weather, which cannot be said of some portions of the Indiana stone used in buildings erected in 1909-10. The Rockwood quarries have most modern and approved methods of machinery for sawing the stone and handling it in transit to the mills and elsewhere. The stone is of massive formation, of great thickness and extent. Blocks weighing as much as 25 tons, without crack or flaw, are not infrequently quarried, the size of the blocks being practically limited only by the capacity of the hoisting machinery.

The Oolitic variety is most extensively used for building and monumental work. It is of light gray color, uniform grain, and homogeneous texture. It possesses a quality of cheapness, it can be cut to any design required, and is at the same time strong and durable.

With the installing of adequate machinery at the quarry for doing the finished work, there should never be any longer any reason for going outside of the State for this quality of stone. Already the material has been very extensively used in public buildings in Mississippi, Tennessee, as well as in Alabama. The only reason why it was not used in the recently erected buildings at the University of Alabama was that at the time these building contracts were let, the quarries furnished only the rough sawn stone and there was not in Alabama any establishment adequately equipped for the dressing of the stone in the quantity needed.

The above statements are confirmed by a report on the comparative tests made on the Rockwood stone, and those from Bedford, Ind., and Bowling Green, Ky., by Prof. Robert H. McNeilly, in the Engineering Laboratory of Vanderbilt University.

From this report I give the following extracts:

"GENERAL CHARACTERISTICS.—The Rockwood limestone is an almost pure oolitic limestone with frequent small crystals of calcite distributed throughout its mass. It resembles closely the Bedford stone in appearance, except that it has a slightly more open texture. The Bowling Green stone is finer in grain, softer and more easily pulverized than either the Bedford or Rockwood stones, and contains an appreciable amount of petroleum, which lends somewhat to the ease with which it is worked. In all three stones the texture is exceptionally uniform, as it is almost impossible to detect the bedding planes by eye; however in this respect the Bowling Green stone is most marked, and it is frequently necessary to test by hammer to detect which is the bed plane. Rockwood stone is lighter in color than either the Bedford or Bowling Green stones.

"CHEMICAL ANALYSIS.—The following is an analysis of the Rockwood stone made at my request by Dr. Paul C. Bowers, Chief Chemist of the Tennessee Geological Department:

	Rockwood Stone.
Moisture and loss on heating to 175° C.	0.07
Insoluble siliceous residue (SiO_2, etc.)	0.49
Oxide of Iron and Alumina (Fe_2O_3 & Al_2O_3	0.30
Carbonate of Lime ($CaCO_3$)	98.23
Carbonate of Magnesia ($MgCO_3$)	0.97
Total	100.06

"PHYSICAL TESTS.—Comparative physical tests of the three samples of stone were made as follows:

Loss in weight on drying,
Cross bending tests,
Compression tests,
Absorption tests,
Per cent of water absorbed,
Specific gravity in bulk, and of pulverized stone,
Density,
Abrasion tests.

The results of these physical tests are summarized in the CONCLUSIONS below quoted.

"CONCLUSIONS.—The above tests were made as nearly as possible, under identical conditions, and barring the accidental characteristics of the samples, which were selected at random, these results are believed to represent truly the comparative characteristics of each of the stones under consideration.

"The Rockwood stone shows itself to be a superior building stone to others in every respect except density—but even here, since its absorption of water is the lowest of the three, it should prove more durable, while the smaller weight per cubic foot can be placed more cheaply on account of freight charges.

"As compared with the Bowling Green stone, the Rockwood shows a decidedly higher strength, and characteristics which indicate a greater durability. The Bowling Green stone, however, is undoubtedly more easily worked than either of the other two stones, due to its being softer and also to the presence of oil. This oil has the bad effect of staining the stone itself and the contiguous masonry for several years after it is placed, while the very ease with which the stone can be worked makes the Bowling Green very inferior where used for door sills and steps. This is shown well by the Abrasion Test which shows the Rockwood stone in its best light, as a very superior material for step, door sills, and other places subject to wear.

"From my examination of these three stones, I believe no builder would make a mistake in using any one of the three, for they are all unquestionably very superior building stones. While each stone may have advantages over the other for some specially desired characteristics, as a building stone for general purposes, each is highly satisfactory.

Respectfully submitted,
Robert H. McNeilley,
Assistant Professor of Civil
Engineering, Vanderbilt University."

Marble.

The marble of Alabama is of two kinds, crystalline, or true marble, and non-crystalline.

The crystalline or statuary marble occurs mainly in a narrow valley along the western border of the metmorphic area, extending from Marble Valley in Coosa County, through Talladega into Calhoun. The length of the marble belt through Coosa and Talladega counties is about 50 miles. The width of the valley carrying the marble as a rule is from one quarter to one-half mile, widening in places to a mile and a quarter, for example in the neighborhood of Sylacauga.

The quarries longest known are Gantt's and Herd's near Sylacauga, Nix's near Sycamore, Bowie's near Rendalia, and Taylor's and McKenzie's near Taylor's Mill, east of Talladega. From all of these marble was quarried before the civil war, During 1916 two companies reported production of marble in Alabama, viz., the Alabama Marble Company at Gantt's Quarry and the Moretti-Harrah Company, whose quarry adjoins that of the Alabama Marble Company at Gantt's. The other quarries mentioned are in Talladega County, near Sylacauga.

The plant of the Alabama Marble Company at Gantt's Quarry which was completely destroyed by fire in December, 1910, has been rebuilt and equipped with all the machinery needed for the working up of any kind of finished product.

I think it is fairly safe to say that on the whole the marble from this quarry and immediate vicinity is of the highest grade of commercial white marble now on the market and obtainable in large quantity. There are small quantities of marble produced both in Italy and Vermont that are somewhat freer from coloring matter than the best grades that can be produced in Alabama in any quantity. But on the other hand, the poorest grades in Alabama greatly surpass the poorest grades produced elsewhere, so that the average of the Alabama deposit is probably somewhat higher than that of any other so far developed, not excluding even the marble from the Carara district in Italy. The marble from this State (Gantt's Quarry) has now a well established reputation and has been used in more than 200 important buildings throughout the United States.

It can be seen in the galleries of the National Museum in Washington.

The Moretti-Harrah Company furnishes the marble in blocks for monumental and rough interior purposes.

A beautiful quality of variegated limestone or marble—red, pink and white—belonging probably to the Cambrian formation, occurs in Shelby County, a mile or two south of Shelby Springs station on the L. & N. railroad, and extending thence southwest for a mile or two. Nothing but prospecting work has been done on this marble. The Trenton limestone in the Appalachian valleys, particularly Jones Valley below Bessemer, contains marble similar to that quarried in the vicinity of Knoxville, Tenn. Also at Pratt's Ferry on the Cahaba River in Bibb County a quarry was for many years worked in this formation and turned out a very beautiful quality of marble varying in color from gray through pink, red and brown shades.

A black marble which is exceedingly promising, has been reported and some development work done near Anniston, and at Piedmont, Calhoun County, and some very handsome specimens of cave onyx have been obtained from near Kymulga in Talladega County.

In the Coastal Plain the St. Stephens limestone of the Tertiary holds ledges of hard, almost crystalline rock capable of taking good polish. The colors vary from nearly white, through shades of yellowish into red, and it would make a handsome decorative marble, especially for inside work.

Other limestone formations, such as the Subcarboniferous and the Knox Dolomite, could in places be drawn upon for marble.

SANDSTONE.

The returns to the U. S. Geological Survey office show a decrease in the total value of the sandstone produced in 1916, of $9,437 or 31.01 per cent, as compared with the 1915 production.

By far the greater part of the sandstone produced in 1916 was ganister.

The following table will show the limestone and sandstone production of Alabama from 1912 to 1916 inclusive:

Value of limestone and sandstone production in Alabama, 1912-1916.

KIND	1912	1913	1914	1915	1916
Limestone	$531,085	$812,664	$787,214	$426,266	$917,559
Sandstone	27,596	151,111	161,773	30,432	20,995

SUMMARY.

BECAUSE of the difference in units of measurement employed in the various branches of the mineral industry, a summation of the production of the year can include only the values of the products. It is also to be noted that a simple summation of all the values of the minerals or mineral products listed in this pamphlet would give a value much in excess of the true value, since in many cases, as for instance coal and coke, and iron ore and pig iron and steel, the second product is directly a product of the first, and the value of the first is included in that of the second. To give the values of both as a part of the total would be to repeat, in a measure, at least a partial value of the first or raw product and would give an erroneous result.

As the Survey has not, however, the figures upon which to base an estimate of the percentage of each product which was used in the manufacture of some other product, the summation of the mineral production of the State as here given will be a simple summation of the values reached by the individual branches of the industry.

According to this rather unsatisfactory manner of summation, which does not include the value of the steel produced, the value of the 1916 raw materials and immediately derived products was $94,987,229, as compared with $61,791,958 in 1915; an increase of $33,195,271, or 53.72 per cent.

This production may be classified as follows:

Raw products	**$40,973,430**
Pig iron	**38,994,660**
Coke	**15,019,139**
Total	**$94,987,229**

The more important minerals and products after coal, pig iron and coke, are iron ores, clay products, stone, cement, sand and gravel, and lime given in the order of their relative importance.

Below is a tabular presentation of the value of the mineral products of Alabama, as estimated above for the years 1911, 1912, 1913, 1914, 1915, and 1916:

Year	Value
1911	$52,772,951
1912	60,141,793
1913	67,530,089
1914	56,769,559
1915	61,791,958
1916	94,987,229

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GEOLOGICAL SURVEY OF ALABAMA

EUGENE ALLEN SMITH, *State Geologist*

BULLETIN NO. 21

STATISTICS OF THE MINERAL PRODUCTION OF ALABAMA FOR 1917

COMPILED FROM THE MINERAL RESOURCES OF THE
UNITED STATES

By
WALTER B. JONES

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LETTER OF TRANSMITTAL

UNIVERSITY, ALA., February, 1920.

HON. THOMAS E. KILBY,
Governor of Alabama,
Montgomery, Ala.

SIR:—I have the honor to transmit herewith the manuscript of a Report on the Mineral Production of Alabama for the year 1917 with the request that it be printed as Bulletin No. 21 of the Geological Survey of Alabama.

Very respectfully,
EUGENE A. SMITH,
State Geologist.

GEOLOGICAL CORPS.

Eugene Allen Smith, Ph. D.	State Geologist
William F. Prouty, Ph. D.	Chief Assistant
Robert S. Hodges	Chemist
Herbert H. Smith	Curator of Museum
Roland M. Harper, Ph. D.	Botanist
A. T. Donoho	Secretary
George N. Brewer	Field Assistant

RIVER GAGE HEIGHT OBSERVERS.

Conecuh River at Beck, Ala.

A. W. Lambert	Route F. Andalusia, Ala.

Coosa River at Riverside, Ala.

J. E. Whitehead	Riverside, Ala.

Tallapoosa River at Sturdevant, Ala.

A. L. Stowe	Alexander City, Ala.

Big Bear River near Red Bay, Ala.

Ed Bullen	Red Bay, Ala.

Observations are made every day by these observers of the gage readings at the several stations. From these records when extended through sufficient time, the calculation of available horse power to be obtained from the different streams is made.

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PREFACE

THE statistics of all the minerals included in the following pages have been collected in co-operation with the United States Geological Survey, and have been compiled from advance chapters of the *Mineral Resources of the United States,* a publication of the Federal Survey.

The introductory and general matter in each of these articles has either been taken without change from the U. S. advance chapters or has been rearranged or condensed from these chapters, or entirely rewritten to suit it to our present purposes. In each case credit is given to the author.

INTRODUCTION

EUGENE ALLEN SMITH.

AN INSPECTION of the subjoined tables will show that there has been in 1917 an increase both in quantity and value of the mineral products of the State, with the exception of gravel, cement, bauxite, mineral waters and sandstone.

Following the plan set out by Mr. E. W. Parker in 1913, and continued by the Alabama Survey, we pass in review the production in 1916 and 1917 of Alabama minerals, and their immediate derived products, taking them up somewhat in the order of their commercial importance.

COAL.—Alabama's production of coal in 1917 was 20,068,074 short tons, valued at $45,616,992, an increase of 10.9 per cent. in the quantity, and of 83.5 per cent. in value as compared with 1916. As in 1916, the value of coal products in Alabama in 1917 was more than three-fifths of the total mineral output of the State.

COKE.—The coke production of Alabama increased from 4,298,417 short tons, valued at $15,019,139 in 1916 to 4,892,589 short tons, valued at $28,394,212 in 1917, an increase in the value of 88.8 per cent.

IRON ORE.—In 1917 there was an increase of 4.3 per cent. in the total quantity of iron ore production in the State as compared with 1916, 4.9 per cent in the quantity of hematite and 1.8 per cent in the quantity of brown ore.

PIG IRON.—In the quantity of pig iron marketed in Alabama in 1917, there was an increase in the quantity from 1916, of 299,128 gross tons, or 11 per cent, and of $25,315,054, or 65 per cent. in the value. The value of the iron ore production, and not the value of the pig iron, is used in making up the total value of the mineral products of the State.

The total value of the mineral production of Alabama, excluding the value of pig iron and coke, and including the value of the iron ores and the coal, was in 1917 $65,423,224, compared with $40,973,430, in 1916, of which, as already stated, more than three-fifths is represented by the products of the coal mines. More than one-fourth of the total value was contributed by the iron mines. The increase in 1917 from 1915 was $35,815,747 or 121.5 per cent.

The principal coal producing counties are Jefferson, Walker, Bibb, Tuscaloosa, and St. Clair, in the order named. The principal iron ore counties are Jefferson, Tuscaloosa, Franklin and Etowah. The combined value of the pig iron and coke made in Alabama in 1917 was $92,703,926. These values are not included in the total as they are represented in the value of the iron ore and coal produced.

CLAY WORKING INDUSTRIES.—These industries yielded products in 1917 valued at $2,106,516 as against $1,520,301 in 1916, an increase of $586,215 or 38.56 per cent. This does not include the value of the raw clay sold, which in 1917 amounted to $84,763, an increase in 1917 of 66 per cent.

The center of the clay-working industry is Jefferson County, and Birmingham furnished the principal market. Vitrified, common, and fire brick, represent a value of $1,377,770, or 66.3 per cent. of the total value, while the total output of the brick yards makes up 71.5 per cent. of the total value of the clay products of the State. All the fire brick is reported from Jefferson, Baldwin and Calhoun counties, and all the vitrified brick is from Jefferson and St. Clair counties. Clay pits for the manufacture of common brick have been opened in one or more places in thirty-two counties.

The pottery products in 1917 consisted of stone-ware, yellow and Rockingham ware, and red earthen ware, including turpentine cups, and represented a value of $18,731, a decrease of $4,074 over 1916, or 17.8 per cent.

STONE.—The quarry products, exclusive of marble, the greater part of which is limestone, valued in 1917 at $1,296,006, an increase from 1916 of $357,452, or 38.1 per cent. This increase was mainly in the limestone used for flux and in lesser degree in limestone for building purposes.

Over 75 per cent. of the total value of the stone production in 1917 is that of limestone. Its most important uses are for furnace flux, concrete, riprap and for building purposes. The production of marble in 1917 was practically the same as that in 1916. The figures of production can not be given because of the limited number of producers.

Marble holds second place in the value of the quarry products. Beautiful white marble occurring in Coosa and Talladega Counties, is extensively used for building work, (both inside and outside). A black marble which gives promise of future development, has been prospected near Anniston and near Piedmont.

The reader is referred to the body of this bulletin, under Stone, for further details concerning especially the building stone and marble industries.

CEMENT.—The cement production of Alabama in 1917 amounted to $1,329,833 barrels, valued at $1,494,879 as against 1,442,475 barrels, valued at $1,410,104 in 1916. This was a decrease of 7.8 per cent. in quantity and an increase of 6.0 per cent. in value.

LIME.—The lime production is not included in that of the limestone. It amounted in 1917 to 66,744 short tons, a decrease from the 1916 production of 780 short tons, or 1.2 per cent. The value of the product is $383,211, an increase from 1916 of $70,680, or 22.6 per cent.

GRAPHITE.—The Alabama graphite is of the crystalline variety, and the value of the product in 1917 was $719,575 as against $492,407 in 1916, an increase of 46.1 per cent. The Alabama product for 1917 was 65 per cent. of the total value for the crystalline graphite for the United States. The great increase in the production and value of the Alabama graphite since 1915, and the installing of a number of new plants in 1916 make it probable that the Alabama production in coming years will represent even a larger proportion of the total United States value.

MINOR PRODUCTS.—Alabama produces a small quantity of barytes, bauxite, mill stones, mineral waters, sand and gravel, quartz, and pyrite.

In the following table there is a comparison of the mineral output in Alabama in the years 1916 and 1917. As stated above, the total does not include the value of the pig iron or that of the coke, but it does include the value of the coal made into coke, and of the iron ore sold or used in making pig iron.

Mineral production of Alabama in 1916 and 1917.

PRODUCT	1916				1917			
	Raw.		Derived.		Raw.		Derived.	
	Quantity.	Value.	Quant'y.	Value.	Quantity	Value.	Quantity.	Value.
Coal, short tons	18,086,197	$24,859,831			20,068,074	$45,616,992		
Coke, short tons			4,298,417	$15,019,189			4,892,589	$28,394,212
Iron ore, long tons	6,801,839	10,843,231			7,101,586	13,049,535		
Pig iron, long tons			2,672,498	33,994,660			2,971,626	64,309,714
Limestone, exclusive of marble		917,559				1,278,908		
Cement, barrels			1,442,475	1,410,104			1,329,833	1,494,879
Lime, short tons			67,524	312,531			66,744	383,211
Marble				*				*
Clay products				1,520,301				2,106,516
Graphite, pounds	5,226,940	492,407			6,228,095	719,575		
Sand and gravel, short tons	726,650	184,216			476,678	222,011		
Clay, short tons	41,479	51,058			58,667	84,763		
Pyrite, long tons					*	*		
Bauxite, long tons	*	*			8,281	52,817		
Sandstone, including ganister		20,995				17,098		
Barytes, long tons	7,631	27,198			1,976	8,358		
Mineral waters, gallons sold	103,944	12,174			56,270	5,509		
Gold, fine ounces, Troy			418	8,650				
Mica, sheet, pounds			14,132	4,955				
Mica, scrap, short tons			65	660				
Manganese ore, long tons	*	*						
Natural gas		*						
Miscellaneous		307,565				383,052		
Total†		$40,978,430				$65,423,224		

*Included in Miscellaneous. †Includes raw and derived, except coke and pig iron.

STATISTICS OF THE MINERAL PRODUCTION OF ALABAMA FOR 1917

ABRASIVES.

EUGENE A. SMITH.

ALABAMA'S production of abrasives is at present limited to a small number of millstones (chasers*) of Pennsylvanian age, quarried and made at Dutton, Jackson County; there are, however, several materials in different parts of the State which are sufficiently promising to be worth investigating and thorough testing; the nature and locality of these deposits were treated in Bulletin No. 13, which see.

BARYTES.

(Condensed from Mineral Resources of the United States.)

JAMES M. HILL.

THE barytes marketed from Alabama in 1917 was 1,976 short tons as compared with 7,631 short tons in 1916, a decrease of 74 per cent. Mines near Angel, in Calhoun County, produced a large part of the barytes sold in 1917, though several hundred tons were produced near Wilsonville, Shelby County, and Leeds, Jefferson County.

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*Chasers are larger than the regular millstones. They are used for heavier work, such as grinding quartz, feldspar, barytes, etc., and they run on edge. Though they are made with a diameter as short as 24 inches, they are usually turned out with diameters ranging from 50 to 84 inches, and are as much as 22 inches in thickness. These chasers are run on pans paved with roughly cubical blocks of the conglomerate, with edges about a foot in length. In grinding quartz in such pans the chasers are used in the preliminary crushing; then rough blocks, usually three in number, are either attached to or carried along by lateral arms, which in turn are joined to a vertical revolving shaft. By the circular movement of these blocks the material placed in the pan is ground to powder.

The deposits near Jacksonville, Calhoun County; Vincent, Harper, and Wilsonville, Shelby County; and Leeds, Jefferson County, were under development, and a considerable production was made from the mine in Jefferson County, at which a steam-driven hoisting plant and log washer is operated. The mine is about 5 miles south of Leeds in the flat valley bottom of Little Cahaba River. The Chickamauga (Pelham) limestones (Ordovician), in which the valley is cut,* strike north-northeast and dip southeast at steep angles. The mining has exposed the very rough surface of the underlying blue-gray limestone, in which barite in irregular masses replaces the lime and magnesium carbonates. The barytes is mined from the red residual clay overlying the limestone and some large masses of barytes have been found, though the great bulk of the barytes ranges from 1 to 4 inches in size and is of high grade.

From 1 to 3 miles north of Angle station and about 12 miles northwest of Jacksonville, Calhoun County, there are a series of barytes deposits on which a little development has been done. These deposits lie at the base of white quartzite ridge in red residual clay that is derived from blue-gray magnesian limestone, whose age has not been definitely determined but which is probably Knox dolomite.

In the vicinity of Vincent, Harpersville, and Wilsonville, eastern Shelby County, there are small irregular masses of barytes in the red residual clays derived from limestone of Beekmantown age.† Shipments have been made from several small pockets, and it is reported that at a number of places indications point to larger bodies.

Details concerning the manufacture of ground barytes, of lithopone, and of barium chemicals and their uses are given in Bulletin No. 19 of the Alabama Geological Survey, and in the Mineral Resources of the United States for 1916. E. A. S.

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*Butts, Charles, U. S. Geol. Survey Geol. Atlas, Birmingham folio (No. 175), 1910.

†Butts, Charles, U. S. Geol. Survey Geol. Atlas, Montevallo-Columbiana folio (in preparation).

BAUXITE AND ALUMINUM.

By JAMES M. HILL.†

BAUXITE.

DOMESTIC PRODUCTION.

THE quantity of bauxite marketed in the United States in 1917 was 568,690 long tons, which had a value at the mines of $3,119,058, an increase over the production of 1916 of about 34 per cent in quantity and about 36 per cent in value. The production from the Georgia, Alabama, and Tennessee field in 1917 was 62,134 long tons, an increase of about 26 per cent, and the Arkansas production of 506,556 long tons showed an increase of approximately 35 per cent.

Bauxite produced and consumed in the United States, 1913-1917.

YEAR.	DOMESTIC PRODUCTION					
	Georgia, Alabama, and Tennessee		Arkansas.		Total	
	Quantity (long tons)	Value.	Quantity (long tons)	Value.	Quantity (long tons)	Value.
1913	40,370	$150,710	169,871	$846,988	210,241	$997,698
1914	24,071	92,508	195,247	976,686	219,318	1,069,194
1915	28,245	144,345	268,796	1,370,489	297,041	1,514,834
1916	49,190	284,810	375,910	2,011,590	425,100	2,296,400
1917	62,134	395,051	506,556	2,724,007	568,690	3,119,058

YEAR	Exports¶		Imports		Domestic consumption	
	Quantity (long tons)	Value	Quantity (long tons)	Value	Quantity (long tons)	Value
1913	21,456	$85,746	*	*	231,697	$1,083,444
1914	24,844	96,500	‡5,374	$240,084	238,788	925,610
1915	3,420	17,107	16,082	717,186	284,379	814,755
1916	30	87	18,032	987,454	407,098	1,309,038
1917	7,760	29,433	21,791	1,323,986	554,659	1,824,565

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†The statistical data in this report were prepared by Miss H. M. Gaylord, of the United States Geological Survey.

¶Includes bauxite concentrates.

*Included in "All other articles."

‡From July 1, 1914, includes bauxite concentrates.

Apparently the producers of aluminum consumed about 375,000 tons, the makers of chemicals about 82,000 tons, makers of abrasives about 110,000 tons, and the makers of refractories about 2,400 tons of bauxite in 1917.

As will be seen by the table, though the domestic consumption of bauxite in 1917 also increased 36 per cent over the consumption in 1916, the domestic deposits were able to supply nearly the whole demand. The larger exports were apparently made to Canadian aluminum and abrasive makers.

MARKET AND PRICES.

The market for bauxite in the United State is east of Mississippi River, and the largest consumers are located at or near the cities of East St. Louis and Aurora, Ill.; Detroit, Mich.; Cincinnati, Ohio; Knoxville, Tenn.; Philadelphia and Erie, Pa.; Niagara Falls and New York City, N. Y.; and Boston, Mass. Recently a number of municipal and industrial waterworks have installed small plants for the manufacture of aluminum sulphate for local use in purification of water. A complete list of those known to the United States Geological Survey to be users of bauxite follows:

USERS OF BAUXITE.

Aluminum Co. of America, Pittsburgh, Pa.
Booth Chemical Co., P. O. Box 203, Elizabeth, N. J.
Carborundum Co., Niagara Falls, N. Y.
Charles Lennig & Co. (Inc.), 112 South Front Street, Philadelphia, Pa.
Charles Taylor Sons Co., Cincinnati, Ohio.
Columbus Waterworks, R. D. 5, Columbus, Ohio.
Cumberland Waterworks, R. D. 3, Cumberland, Md.
Detroit Chemical Works, 238 Junction Avenue, Detroit, Mich.
E. I. du Pont de Nemours Powder Co., Wilmington, Del.
Erie Chemical Works, 31 Union Square W., New York, N. Y.
Exolon Co., 156 Sixth Street, Cambridge, Mass.
General Abrasives Co., Niagara Falls, N. Y.
General Refractories Co., Trinity Building, New York, N. Y.
Harbison-Walker Refractories Co., Pittsburg, Pa.
Jerecki Chemical Co., St. Bernard Station, Cincinnati, Ohio.
Laclede-Christy Clay Products Co., St. Louis, Mo.
Masillon Stone & Fire Brick Co., Masillon, Ohio.
Merrimac Chemical Co., 33 Broad Street, Boston, Mass.

Metropolitan Water District of Omaha, Omaha, Nebr. (R. B. Howell, general manager.)

Montclair Waterworks, Little Falls, N. J.

Norton Co., Worcester, Mass. (also Niagara Falls, N. Y.)

Pennsylvania Salt Manufacturing Co., Widener Building, Philadelphia, Pa.

Springfield Waterworks, Springfield, Mass.

Superior Chemical Co., Joliet, Ill.

Bauxite is graded according to its chemical composition and is sold to the consuming industries on the basis of analysis. Apparently low content of silica and titanium is essential to the aluminum industry, but the content of iron may be fairly high, though bauxites low in iron and titanium are preferred by the makers of alum and aluminum sulphate. Makers of abrasives appear to be able to use bauxites of lower grade and containing larger proportions of silica and iron than are permissible in bauxite for other uses, but most abrasives are made from bauxites low in silica and iron. The bauxite used for refractories must apparently be fairly low in iron.

The prices received for bauxite in 1917, as reported by producers, ranged from $4.75 to $10.50 a long ton; the average price paid for the whole of the domestic bauxite sold in the country was $5.48 a long ton at the shipping point.

OCCURRENCE AND CHARACTER OF BAUXITE IN THE UNITED STATES.

The known commercial bauxite deposits of the United States are in Calhoun, Cherokee, and DeKalb counties, Ala.; Pulaski and Saline counties, Ark.; Bartow, Floyd, Meriwether, Sumter, and Wilkinson counties, Ga.; and Carter and Hamilton counties, Tenn. A brief description of the geology of the domestic deposits was given in the report for 1916,* and detailed descriptions of the deposits in central Georgia have been published by the Georgia Geological Survey.†

The bauxite from all localities in the United States, though it may vary in chemical composition, is on the whole similar in general appearance, with the exception of the "granitic bauxite" of the Arkansas field. The greater part of the American bauxite appears to be made up of rounded pebble-like bodies set in a fine-grained matrix, which may also consist of small rounded particles or may be as fine grained as the finest clay. The pebble or pisolite form is so general that it is the conspicuous characteristic of American bauxite.

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*Hill, J. M., Bauxite and aluminum in 1916: U. S. Geol. Survey Mineral Resources, 1916, pt. 1, pp. 161-165, 1917.

†Shearer, H. K., A report on the bauxite and fuller's earth of the Coastal Plain of Georgia: Georgia Geol. Survey Bull. 31, 1917.

There is only one way to determine the value of bauxite, and that is by chemical analysis, which should show total silica, alumina, titanium oxide, iron oxide, and water. Bauxite of commercial grade should carry at least 52 per cent of alumina.

A few characteristics that indicate in a general way the quality of bauxite may be mentioned, though none of them are to be depended on. In general, bauxite of fair grade will not show the marks of a hammer when it is hit a glancing blow, though some bauxite has been shipped which can be cut with the hammer. Good bauxite that has been dried either in the open or in kilns when thrown on a hard floor has a distinct rattle, which bauxite clay does not have. The pistolites of the lighter-colored bauxites of the central Georgia field have a peculiar brownish-buff color and look something like horn or flint; they ordinarily can not be broken or marked with the finger nail in bauxites of good grade.

Some measure of the relative quality of dried bauxite can be had by grinding a sample in an agate mortar for half a minute. A bauxite of good grade will be found hard to grind and will stick to the mortar with such tenacity that it will have to be scoured out; a poor bauxite or bauxitic clay will grind much more easily and will stick very little, if at all; and clay or kaolin grinds with ease and does not stick to the mortar. Similar results are found if the sample is rubbed on glass; the glass will not be scratched by even high-grade bauxite.

NOTES ON THE UNITED STATES BAUXITE MINES.

Alabama.—During 1917 three companies were operating in the Alabama field—the E. I. du Pont de Nemours Co., at the Snider mine, north of Piedmont, but in Cherokee county; the Republic Mining & Manufacturing Co., near Rock Run, Cherokee County; and the Consolidated Mining Co., near Fort Payne, DeKalb County.

The production of bauxite from Alabama in 1917 showed an increase of about 44 per cent over the production in 1916. The output was used for the manufacture of alumina chemicals to the extent of 53 per cent; abrasive, 44 per cent; and refractories, 3 per cent.

Arkansas.—The American Bauxite Co., Globe Bauxite Co., E. I. du Pont de Nemours Co., and Republic Mining & Manufacturing Co. mined bauxite from deposits in Saline and Pulaski counties, Ark. The largest production was made from the deposits near Bauxite, Saline County.

The production from Arkansas in 1917 showed an increase of 35 per cent over the production in 1916, and it is believed that should the demand arise the Arkansas deposits are capable of much greater output and contain considerable reserves. The bauxite mined from the Arkansas deposits is of high grade, as is shown by the fact that more than 71 per cent of the output in 1917 was used for the manufacture of aluminum, nearly 19 per cent from abrasives, 9 per cent for chemicals, and 1 per cent for refractories.

Georgia.—The total production of bauxite from Georgia in 1917 was approximately 52,000 tons, an increase of about 31 per cent over the production in 1916. Wilkinson County produced the largest quantity, Sumter County was second, Floyd County third, Bartow County fourth, and Meriwether County fifth in rank of output.

Georgia bauxite appears to be more suitable for the manufacture of alumina chemicals than for other purposes. The output in 1917 was distributed as follows: 59 per cent for alumina chemicals, 21 per cent for aluminum, and 20 per cent for abrasives.

In Bartow and Floyd counties in 1917 five companies were mining bauxite from deposits near Adairsville, Cave Springs, Hall, Hermitage, Linwood, and Pinson. The total quantity of bauxite shipped from the north Georgia area was approximately 15,000 tons, of which approximately 53 per cent was used for alumina chemicals, 33 per cent for abrasives, and 14 per cent for aluminum.

There was a small production of bauxite from the deposits near Warm Springs, in Meriwether County, which was used for alumina chemicals. It is reported that an eastward extension of these peculiar deposits has been found and will be developed during 1918.

In the central Georgia field three operators reported production of bauxite from deposits in Sumter County and five operators from deposits in Wilkinson County. The production of bauxite from this area was approximately 37,000 long tons, of which 61 per cent was used for alumina chemicals, 23 per cent for aluminum, and 16 per cent for abrasives.

Tennessee.—The bauxite deposits on Missionary Ridge were reported idle during 1917. A small output was made at the mines near Elizabethton, Carter County, but car shortage hampered operations. A new deposit of bauxite has been discovered near Hixon, 15 miles north of Chattanooga.

ALUMINUM.

DOMESTIC PRODUCTION AND CONSUMPTION.

The value of primary aluminum produced in the United States in 1917 was $45,882,000, an increase of 35 per cent over the value of the output in 1916. This increase is due in part to the increased price and in part to the greater output of primary aluminum in 1917. No estimate can be made at this time (March, 1918) of the recoveries of secondary aluminum during 1917, but the data at hand, though incomplete, indicate that the recoveries will not be smaller than in 1916. Information concerning this phase of the aluminum industry will be found in the chapter of Mineral Resources on secondary metals in 1917, which is now in preparation.

Value of aluminum produced and consumed in the United States, 1913–1917.

YEAR	Domestic production		Imports¶	Exports‖	Apparent consumption
	Primary metal	Secondary metal†			
1913	$9,450,000	$2,199,480	$3,845,611	$966,094	$14,528,997
1914	10,080,000	1,673,140	2,801,211	1,546,510	13,007,841
1915	16,280,000	5,802,100	1,808,193	3,682,117	20,208,176
1916	33,900,000	23,430,200	1,785,870	15,417,134	43,698,936
1917	45,882,000	*	56,880	14,586,468	†31,352,412

‡Value based on average open market price, as quoted by Eng. and Min. Jour.

¶Imports for consumption, figures from Department of Commerce reports. Includes aluminum in crude form, leaf, sheets,, plates, bars, strips, wire, rods, and all manufactures of; table, kitchen, and hospital ware.

‖Exports of aluminum and manufactures of; figures from Department of Commerce reports.

*No statistics available.

†This includes primary metal alone in 1917.

MARKET AND PRICE OF ALUMINUM.

In the United States the quoted prices for primary or "virgin" aluminum ranged from 62 cents a pound, in January, to 37 cents a pound, in October, a price which was maintained to the end of the year. The average for the year was 51.59 cents a pound, as compared with 60.71 cents in 1916. These prices are for small lots and immediate delivery, offered in the open market, and do not represent the price received by the single producer of primary aluminum in this country.

Prices of aluminum, 1913–1917, in cents per pound.†

YEAR	Average open market price, small lots	Contract price
1913	23.64	*
1914	18.63	*
1915	33.98	20–31
1916	60.71	31–37
1917	51.59	31–37

†Eng. and Min. Jour. quotations in annual review numbers.

*No figures published, but it seems reasonable to believe that contracts were made on approximately the same basis as for 1912.

On March 5, 1918, announcement was made in the papers of Washington, D. C., that the President had fixed the maximum base price of virgin aluminum, 98-99 per cent pure, for lots of 50 tons or over, at 32 cents a pound. This price is subject to revision June 1, 1918.

Secondary aluminum, 98-99 per cent pure, recovered from scrap materials, sold for 56.40 cents a pound at the beginning of 1917. Its price followed the decline of virgin metal to a low of 35 cents a pound in the latter part of October, a price which was maintained to the end of 1917.

NOTES ON THE ALUMINUM INDUSTRY.

The Aluminum Co. of America is now operating four electrolytic plants in the United States at which aluminum is made—at Massena and Niagara Falls, N. Y., Maryville, Tenn., and Badin, N. C. The Badin plant made its initial run in 1916, but was not producing much aluminum until August, 1917. Additional power is under development for the Maryville plant, which will further increase the producing capacity of the United States.

The British Aluminum Co. is reported* to be enlarging its aluminum works at Kinlochleven, in Scotland, On February 28, 1917,† the ministry of munitions took under control the secondary aluminum industry, establishing prices for purchase and resale of various grades of remelted materials containing aluminum and issuing rules for the makers and refiners of such materials, called "aluminum scrap and swaf.' It will be recalled that the primary aluminum industry was placed under control December 7, 1915.

USES OF ALUMINUM.

The uses of aluminum have been changed somewhat by war conditions. Pleasure-car automobile makers have restricted the use of metal in bodies and parts of various kinds. Four makers of pleasure cars are making aluminum-alloy engines. Much aluminum is being used for military equipment of all kinds. It is believed that the domestic producers will be able to supply the demand for 1918,‡ but uncertainty as to what the demand will be makes predictions dangerous.

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*Eng. and Min. Jour., vol. 103, p. 880, May 19, 1917.
†Min. Jour. (London), vol. 116, p. 129, Mar. 3, 1917.
‡Aluminum industry in 1917: Metal Industry, vol. 16, p. 21, January, 1918.

OTHER BAUXITE PRODUCTS.

Nearly 65 per cent of the domestic output of bauxite in 1917 went into aluminum, manufacturers of aluminum salts used nearly 13 per cent, 19 per cent was consumed in the manufacture of bauxite abrasives, and 3 per cent was used by makers of "high-alumina refractories," also called bauxite brick.

Within the last two years many foreign and domestic patents have been issued relating to the use of bauxite in the fixation of nitrogen, the manufacture of aluminum salts, and the fabrication of abrasives and refractories. Copies of these patents may be obtained from the United States Patent Office, Washington, D. C.

ALUMINUM SALTS.

The principal aluminum salts made in the United States are alumina, alums, usually ammonium and sodium alums, aluminum sulphate, and aluminum chloride. Alumina is largely consumed in the manufacture of aluminum, and no figures of domestic production are available for publication.

Alums of various qualities are produced at 9 plants in the eastern United States, the total production of alum in 1917 being 19,714 short tons, valued at $1,017,083, a decrease of approximately 28 per cent in quantity and of 14 per cent in value from the production in 1916. The average price reported by makers of alums was $51.60 a short ton. The wholesale market quotations ranged from 4 to 5⅛ cents a pound, or $80 to $102 a short ton. The quotations on lump alum were fairly constant at 4 to 4¼ cents up to May, when an increase to 4½ to 5 cents was made. This price remained steady till November, when it dropped to 4 to 4½ cents. Ground alum at the first of the year was quoted at 4⅛ to 4⅜ cents, but prices rose to 4⅝ to 5⅛ cents about the middle of May and remained stationary until the last of September, when they began to drop, and reached 4 1/10 to 5 cents at the end of 1917.

Aluminum sulphate is made at 24 plants, 7 of which are at municipal or industrial waterworks, which consume their entire output. The total quantity of aluminum sulphate produced in the United States in 1917 was 178,738 short tons, of which 4,947 short tons did not enter the market but was used for water purification at the place of manufacture. The quantity of domestic aluminum sulphate which entered the market, 173,791 short tons, was greater than the quantity in 1916 by approximately 18 per cent, and the total domestic production increased about 16 per cent. The price reported by makers of aluminum sulphate for the 1917 output averaged $32.15 a short ton. Market quotations for low-grade aluminum sulphate ranged from a low of 2 cents to a high of 4 cents a pound, or $40 to $80 a short ton. Low-grade aluminum sulphate was quoted at 2 to 2½ cents a pound until October, when quotations rose to 2 to 3½ cents, but fell to 2 to 3 cents during the second week of November, and closed at 1¾ to 2¼ cents a pound at the end of the year.

Aluminum chloride is used for various purposes, among which may be mentioned the refining of mineral oils. This salt was produced at 3 plants in 1917, and the total output reported to the Geological Survey was 4,702 short tons, valued at $311,900, or approximately $66 a short ton. Market quotations on aluminum chloride remained stationary throughout the year at 4 to 4 1/10 cents a pound, or $80 to $82 a short ton.

Alum and aluminum sulphate produced in the United States and aluminum salts imported, 1913–1917.

YEAR	PRODUCTION						IMPORTS*	
	Alum			Aluminum sulphate				
	Quantity (short tons)	Value	Price per ton	Quantity (short tons)	Value	Price per ton	Quantity (short tons)	Value
1913	9,605	$312,822	$32.57	157,749	$2,977,708	$18.88	2,702	$66,549
1914	18,238	565,989	31.03	164,954	2,942,572	17.84	2,891	78,028
1915	24,915	699,256	28.07	169,153	3,224,495	19.06	1,408	34,320
1916	27,257	1,177,881	43.21	153,860	4,410,741	28.67	1,247	68,660
1917	19,714	1,017,088	51.60	178,738	5,746,427	32.15	507	39,088

*Includes alumina, aluminum hydrate or refined bauxite, alum, alum cake, aluminum sulphate, aluminous cake, and alum in crystals or ground.

BAUXITE ABRASIVES.

Bauxite abrasives sold under various trade names, such as alundum, aloxite, exolon, and lionite, are made by fusing bauxite in an electric furnace. These products are sold in the form of powders, colth, grinding stones, and wheels of various shapes for a multitude of uses.

The total marketed production of artificial abrasives made from domestic bauxite in 1917 was 48,460 short tons, valued at approximately $6,970,000, or about $144 a short ton. This is an increase over the production in 1916 of 58 per cent in quantity and of 200 per cent in value. The average value is deceptive, however, in that the prices received for the product depend on many factors, among which hardness, size of grain, degree of finishing, and many others may be mentioned.

HIGH-ALUMINA REFRACTORIES.

There are two classes of high-alumina refractories now on the market. What are commonly called bauxite brick are made by mixing various proportions of calcined bauxite or high-alumina clay with a bonding material such as fire clay, sodium silicate, or lime. Refractories of this character are being made by the Laclede Christy Clay Products Co., the Harbison Walker Refractories Co., Charles Taylor & Sons, and the Masillon Stone & Fire Brick Co. Not all the refractories made by these companies are sold as bauxite brick, and in fact some do not contain bauxite. The other class of high-alumina refractories consists of those made by the electric fusing of bauxite. These are manufactured by the companies that make artificial abrasives.

The use of high-alumina refractories seems to be expanding, particularly in the construction of copper, iron, and lead furnaces and of cement kilns. No figures are now (March, 1918) available to show the production of high-alumina refractories, though it is known that at least 2,313 long tons of bauxite was consumed in making refractories.

CEMENT.

EUGENE A. SMITH.

PORTLAND CEMENT.

RESOURCES.

ALABAMA contains large supplies of limestone, chalk, clay and shale well adapted to Portland cement manufacture, and widely distributed throughout the State. Coal and labor are abundant and cheap, transportation facilities are excellent, and many of the best limestone and chalk localities are situated on navigable rivers, giving ready access and cheap water transportation to Galveston, New Orleans, Mobile, Charleston, and other ports of the Gulf and Atlantic Coasts. This advantage of location was immensely increased with the opening of the Panama Canal for cement plants located in Alabama are more than a thousand miles nearer to the Isthmus than their nearest possible competitors.

The limestones and shales of the northern part of the State lie so close to each other, and above all so close to the great coal mines which must supply the fuel, that the establishment of Portland cement plants near the coal mines would give to this industry in Alabama the same advantages which the proximity of the iron ore, the coal, and the stone has given to the iron industry, and which has placed our State beyond competition.

As a Portland cement mixture, ready for burning, consists approximately of 75 per cent lime carbonate and 25 per cent of clayey matter, the material furnishing the lime carbonate is necessarily of more economic importance than that from which the silica and alumina are derived. In consequence, a Portland cement plant is usually located in the immediate vicinity of a suitable limestone, while the clay or shale required to complete the mixture may be brought some distance.

The limestone formations in North Alabama which can supply the stone adapted for use in cement manufacture are the Trenton or Pelham limestone and the Bangor or Subcarboniferous. In close proximity to both these limestone formations are the shales of the Clinton, Subcarboniferous and Coal Measures.

At the present time there are two cement plants in North Alabama, namely, the Standard Portland Cement Co., located at Leeds in Jefferson County, and the Coosa Portland Cement Co., located at Ragland in St. Clair County. Both of these plants make use of the hard Trenton limestone, and the Standard Cement Co., according to Burchard of the U. S. Geological Survey, uses the shale of the Clinton formation whilst the Ragland Company makes use of the shales of the Coal Measures. Up to the present time no establishment is utilizing the Bangor limestone.

In Middle Alabama the soft, chalky Cretaceous limestone of the Selma Chalk, is the material utilized by the Alabama Portland Cement Co., at Spocari, near Demopolis. The same company makes use of residual clays overlying and derived from the weathering of the Selma Chalk. During 1915, and since, there was no production from the Demopolis plant.

In Southern Alabama the St. Stephens limestone outcropping east and west across the State, furnishes excellent material for Portland cement manufacture, using either residual clays from decomposition of the limestone, or the clays of the Grand Gulf formation which are almost everywhere in close proximity to the limestone.

PUZZOLAN CEMENT.

During the past seven years only one establishment in Alabama, the Southern Cement Company, North Birmingham, has been engaged in the manufacture of slag cement, using the material from the furnaces about Birmingham. The production is included in the returns for Portland cement and cannot be given separately.

Owing to the fact that there was in Alabama in 1917 only one producer of puzzolan cement, and not more than two operating plants in the Portland cement industry, it is necessary to combine the productions of the two industries in order to avoid publishing figures which were given to the Survey in confidence. The tabular results of such a combination are, however, necessarily inconsistent and not to be taken too literally, since the weights per barrel of the two kinds of cement vary.

The total quantity of Portland and Puzzolan cement sent to market in Alabama in 1917, was 1,329,833 barrels, valued at $1,494,879, as compared with 1,442,475 barrels, valued at $1,410,104 in 1916; a decrease of 112,642 barrels, or 7.81 per cent, and an increase in value of $84,775 or 6.01 per cent.

Below in tabular form are given the foregoing figures:

Quantity and value of Portland and Puzzolan cement, marketed in Alabama in 1916 and 1917.

	No. of Producers	Quantity (Bbls.)	Value
1916	3	1,442,475	$1,410,104
1917	3	1,329,833	1,494,879
Increase or decrease		— 112,642	+ 84,775
Per cent of increase or decrease		— 7.8	+ 6.0

RECOVERY OF POTASH FROM PORTLAND CEMENT MATERIALS.

It has been noticed that the flue dust in a cement plant often contains notable percentage of potash, and efforts have been made to utilize this dust in the extraction of potash. Flue dust from the Standard Cement Plant shows 2½ per cent and above potash, and it is in contemplation to utilize this, and the suggestion is also made to use feldspar in the manufacture. Up to the present time, however, there has been no commercial production of any potash from this source.

CLAY AND CLAY PRODUCTS.

CLAY.

JEFFERSON MIDDLETON AND EUGENE A. SMITH.

CLAY available for the manufacture of clay products is one of the most widely distributed of our minerals. Hence there are clay-working plants scattered over every State and Territory in the Union. Miners of the low-grade clays are usually also the manufacturers, but as the higher grades of ware are reached, the rule is that fewer and fewer manufacturers are also miners, until in the highest grades of ware the rule is that the manufacturer buys and does not mine the clay he uses. The figures given in the following tables represent clay that is mined and not manufactured by the miner, but is sold as clay. The clay thus sold is small in quantity compared with the total production and includes mainly clay used for high-grade pottery and tile, for paper making, and for refractory products.

The total amount of clay mined in Alabama and sold as such in 1917 was 58,667 short tons valued at $84,763. This was an increase in quantity of 17,188 short tons or 41.4 per cent, and of $33,710 or 66 per cent in value as compared with 1916.

Below is a table giving the production and value of clay mined and sold in Alabama from 1908 to 1917 inclusive, and a comparison of the production of 1916 and 1917:

Production of clay in Alabama from 1908 to 1917 inclusive, and a comparison of the production in 1916 and 1917.

YEAR	FIRE CLAY		MISCELLANEOUS CLAY		TOTAL	
	Quantity Short Tons	Value.	Quantity Short Tons	Value.	Quantity Short Tons	Value
1908	68,289	$48,983	24,000	$12,000	92,289	$60,983
1909	45,137	35,345	18,271	5,587	63,408	40,932
1910	54,482	32,395	20,600	5,650	75,082	38,045
1911	35,203	29,909			35,203	29,909
1912	38,552	31,414	4,500	2,000	43,052	33,414
1913	49,901	53,269	*	*	49,901	53,419
1914	27,973	34,607			27,973	34,607
1915	31,520	34,882	*	*	31,870	35,282
1916	40,235	50,618	1,244	435	41,479	51,053
1917	41,951	67,674			58,667	84,763
Increase	1,716	17,056			17,188	33,710
Percentage	4.2	33.7			41.4	66.

*Not divulged but included in total.

In 1916 the average value of the fire clay of Alabama was $1.26 per short ton, and the value of the fire clay production of the State was 1.37 per cent of the total value of the United States production. In 1917 the average value of the Alabama fire clay was $1.61 per short ton, and the value of the Alabama product was 1.2 per cent of the total value of the fire clay produced in the United States.

CLAY PRODUCTS.

The State of Alabama is rich in clays of many kinds, yet its rank as a clay working State is low, being twenty-fifth in 1916. It advanced, however, to nineteenth in 1917. Its clay products in that year reported by 53 operators were valued at $2,106,516—brick and tile, $2,087,785; pottery, $18,731—an increase over 1916 of $586,215, or more than 38.56 per cent. Alabama ranked ninth in quantity and in value of vitrified brick, or block. Its principal clay product was common brick, valued at $557,920, or 26.7 per cent of the State total, an increase over 1916 value of $60,474. The quantity of common brick marketed in 1917 was 81,574,000 brick, a decrease of 4,091,000 brick.

Fire brick, including silica fire brick was Alabama's clay product of second value, a total of 19,815,000, valued at $502,936.

Vitrified brick was third, with 21,319,000 brick, valued at $316,914, a decrease from 1916 of 3,824,000 in quantity, and an increase of $5,597 in value.

Jefferson County was the principal clay-working county, nearly all of the fire and vitrified brick or block produced in the State coming from this county. The principal common-brick-producing counties, named in the order of the value of their output were Jefferson, Montgomery and Talladega.

In tabular form these statistics are given as follows:

Clay products of Alabama, 1912–1917.

PRODUCT.	1912	1913	1914	1915	1916	1917
Brick:						
Common—						
Quantity	136,989,000	130,928,000	110,781,000	70,681,000	85,655,000	81,574,000
Value	$759,409	$730,148	$638,666	$382,092	$497,446	$557,920
Average per M.	$5.54	$5.58	$5.77	$5.41	$5.81	$6.84
Vitrified:						
Quantity	26,480,000	24,183,000	18,679,000	29,018,000	25,143,000	21,319,000
Value	$353,303	$361,722	$248,525	$374,337	$311,317	$316,914
Average per M.	$13.34	$14.96	$13.31	$12.90	$12.38	$14.87
Front—						
Quantity	10,629,000	*	*	5,815,000	6,968,000	*
Value	$132,033	*	*	$58,212	$77,470	*
Average per M.	$12.42	$15.29	$11.42	$10.01	$11.12	$12.17
Fancy, value	*	—	*	—	—	—
Fire, value	$240,434	*	$167,021	$145,535	$278,749	$502,936
Draintile, value	$5,465	$10,802	$6,838	$9,330	*	$17,261
Sewer pipe, value	*	*	*	*	*	*
Fireproofing, value	*	*	*	$62,114	$80,523	$106,700
Tile, not drain, value	—	*	—	—	—	—
Pottery:						
Red earthenware, including turpentine cups, value	$10,990	$11,164	$4,800	$6,741	$13,551	$6,060
Stoneware and yellow and Rockingham ware, value	$11,223	$8,994	$11,742	$8,556	$9,254	$12,671
Miscellaneous,† value	$422,322	$968,751	$496,431	$146,055	$251,991	$488,054
Total value	$1,935,179	$2,091,581	$1,574,023	$1,193,022	$1;520,301	$2,106,516
Number of active firms reporting	74	68	70	65	57	58
Rank of State	17	16	20	24	25	19

*Included in "Miscellaneous." †Miscellaneous includes drain tile, sewer pipe, stove lining and silica brick.

Value of the clay products of Alabama in 1916 and 1917, with increase or decrease.

	BRICK AND TILE	POTTERY	TOTAL
1916	$1,497,496	$22,805	$1,520,301
1917	2,087,785	18,731	2,106,516
Increase or decrease:			
Value	590,289	— 4,074	586,215
Per cent	+ 39.4	— 17.8	+ 38.6

Pottery products of Alabama are of minor importance, constituting less than 1 per cent of the value of clay products. Production was reported in 1917 by eleven firms. The output was valued at $18,731, a decrease of $4,074, or 17.8 per cent as compared with 1916. The products consisted of stone ware and yellow and Rockingham ware, and red earthen ware, including turpentine cups, etc. The latter represents a very notable proportion of the total product. The rank of Alabama in the pottery industry in 1917 was 17.

Comparison of pottery products in 1916 and 1917.

KIND	1916	1917	Increase or decrease	Percentage
Red earthenware	$13,551	$6,060	— $7,491	— 55.3
Stoneware and Rockingham ware	9,254	12,671	+ 3,417	+ 37.0
Total	$22,805	18,731	— 4,074	— 17.8

*Including turpentine cups, vases, etc.

COAL.

E. W. PARKER AND C. E. LESHER.

INTRODUCTORY.

THE great Appalachian coal region which furnishes over two-thirds of the coal production of the United States and which extends from Ohio and Pennsylvania on the north in a gradually narrowing belt through eastern Kentucky and Tennessee has its southern terminus in a considerably broadened area that occupies a large part of the northern half of Alabama. The coal-bearing formations of Alabama underlie about 8,400 square miles and are divided into four distinct basins, the Coosa, the Cahaba, and the Warrior, named from the rivers which drain them, and the Plateau, which includes Blount, Lookout, and Sand or Raccoon Mountains. By far the most important basin in area and in production is the Warrior, which includes all of Walker County, most of Jefferson, Tuscaloosa, and Fayette counties, and smaller parts of Blount, Cullman, Winston and Marion counties. The area known to contain coal is approximately 4,000 square miles, or one-half the total coal area of the State, and contributes about 85 per cent of the total production.

There are several distinct coal groups in the basin, the most important of which are the Brookwood, the Pratt, and the Mary Lee, designated by the names of their principal beds. The Mary Lee group includes the Blue Creek, the Jagger, and the Newcastle beds, most of which are mined in places. The Brookwood, the Pratt, and the Mary Lee produce most of the coking coal mined in the State, and more than half of all of the coal mined in the district.

The Cahaba Basin, second in importance, is a long narrow syncline, 68 miles long and about 6 miles wide, southeast of the Warrior, and occupies parts of St. Clair, Jefferson, Shelby and Bibb counties. There are many workable beds, and the total quantity of coal in the basin is large. The production is something over 15 per cent of the total for the State.

The Coosa Basin is a deep syncline east of the Cahaba and parallel with it, extending across Shelby and St. Clair counties. It is also long and narrow, 60 miles long by 6 miles wide. It has not been thoroughly explored, but in different parts of the area from two to twelve beds, 3 or more feet in thickness, have been reported.

The Plateau field embraces parts of Blount, Etowah, DeKalb, Cherokee, Marshall, and Jackson counties, and although it has an area underlain by coal four times that of the Cahaba and the Coosa combined, the resources in Alabama are comparatively small. There are four to six beds locally workable. So far as known, the earliest record of the existence of coal in Alabama was made in 1834. The first statement of production in the State is contained in the United States census report for 1840, in which year the production is given at 946 tons. The census report for 1850 does not mention any coal production for the State, and the next authentic record is contained in the census statistics of 1860, when Alabama is credited with an output of 10,200 short tons. The mines of Alabama were probably worked to a considerable extent during the Civil War, but there are no records of the actual production until 1870, for which year the United States census reports a production of 11,000 tons. Ten years later the production had increased to 323,972 short tons, but the development of the present great industry really began in 1881 and 1882, when attention was directed to the large iron deposits near the city of Birmingham and thus the great "boom" of that city and vicinity was inaugurated. By 1885 the coal production of the State had increased to nearly 2,500,000 tons. Then followed a period of relapse and liquidation, which lasted two years, after which business settled down to a conservative and rational basis and has since developed steadily. In 1902 the coal production of the State reached a total of more than 10,000,000 tons, and reached the maximum of 17,678,522 tons in 1913, since which time there has been a decrease, until 1916, when the maximum of 1913 was exceeded, as may be seen in table below.

PRODUCTION.

The statistics of production in Alabama from 1840 to the close of 1917 are shown in the following table:

Production of coal in Alabama from 1840 to 1917 in short tons.

Year	Quantity	Year	Quantity	Year	Quantity	Year	Quantity
1840	946	1860	10,200	1880	323,972	1900	8,394,275
1841	1,000	1861	10,000	1881	420,000	1901	9,099,052
1842	1,000	1862	12,500	1882	896,000	1902	10,354,570
1843	1,200	1863	15,000	1883	1,568,000	1903	11,654,324
1844	1,200	1864	15,000	1884	2,240,000	1904	11,262,046
1845	1,500	1865	12,000	1885	2,492,000	1905	11,866,069
1846	1,500	1866	12,000	1886	1,800,000	1906	13,107,963
1847	2,000	1867	10,000	1887	1,950,000	1907	14,250,454
1848	2,000	1868	10,000	1888	2,900,000	1908	11,604,593
1849	2,500	1869	10,000	1889	3,572,983	1909	13,703,450
1850	2,500	1870	11,000	1890	4,090,409	1910	16,111,462
1851	3,000	1871	15,000	1891	4,759,781	1911	15,021,421
1852	3,000	1872	16,800	1892	5,529,312	1912	16,100,600
1853	4,000	1873	44,800	1893	5,136,935	1913	17,678,522
1854	4,500	1874	50,400	1894	4,397,178	1914	15,593,422
1855	6,000	1875	67,200	1895	5,693,775	1915	14,927,937
1856	6,800	1876	112,000	1896	5,748,697	1916	18,086,197
1857	8,000	1877	196,000	1897	5,893,770	1917	20,068,074
1858	8,500	1878	224,000	1898	6,535,283		
1859	9,000	1879	280,000	1899	7,593,416	Total	323,629,988

Coal produced in Alabama, 1912–1917, and increase in 1917.

YEAR	Quantity (Net tons)	Value
1912	16,100,600	$20,829,252
1913	17,687,522	23,083,724
1914	15,593,422	20,849,919
1915	14,927,937	19,066,043
1916	18,086,197	24,859,831
1917	20,068,074	45,616,992
Increase 1917	1,981,877	20,757,161
Percentage of increase, 1917	+11.	83.5

The production of coal in Alabama in 1917 was 20,068,074 tons, valued at $45,616,992, an increase compared with 1916 of 1,981,877 tons, or 11 per cent, in quantity and of $20,757,161, or 83 per cent, in value. This was the record year for production of coal in this State. The increase was shared by all counties except Etowah and Tuscaloosa. Jefferson County, with a gain of 600,000 tons, and Walker County, with 900,000 tons, showed the largest increase in quantity produced.

The demand for coal from the mines of Alabama exceeded the supply throughout the year. For the manufacture of coke to supply the demand of the iron and steel industry, 7,638,000 tons of coal were furnished, an increase over 1916 of 12 per cent, and the railroads of the South used in 1917 about 5,700,000 tons of coal from Alabama, an increase of about 1,100,000 tons, or 21 per cent over 1916, the two industries taking substantially all of the increase in production in the State, with the result that other commercial industries and domestic consumers suffered a real shortage, particularly in the more than ordinarily severe winter of 1917-18.

The average number of days worked in 1917 was 273, a record for the State and equaled by one other State, Virginia, and exceeded only by New Mexico in 1917. This represents about 90 per cent full time operation, if the number of working days in a year be taken as 304. The accompanying graphic representation (Fig. 24) of working conditions as compiled from weekly reports furnished by the majority of the operators from the last of July to the end of the year indicates approximately the same percentage in the last half of the year. That car shortage and transportation difficulties had but little effect on production and that the most important factor limiting output was labor trouble is shown by this diagram. Strikes in August and September and again in December resulted in a decrease in production and are shown clearly in figure 24. The record of strikes for the year shows 1,835 men affected for an average of 6 days, or 10,220 men-days lost. The loss, though but 0.1 per cent of the total men-days worked was, for Alabama, a non-union

State, very large. The record for 1916 was 920 men-days lost, and for 1915, 1,290 men-days lost.

The increase in production was affected by the greater number of days worked (from 262 in 1916 to 273 in 1917); for, although the number of men employed increased from 25,308 to 28,386, the efficiency of the labor as indicated by the average output per man per day fell from 2.73 tons in 1916 to 2.6 tons in 1917 and the average annual production per employee fell from 715 to 707, notwithstanding the greater number of active days. This is partly accounted for by the fact that of the total increase in men employed (3,078, or 12 per cent), more than half (1,606) were surface men. The increase in total number of men was 12 per cent, in underground employees 7 per cent, and in surface employees 42 per cent. The men working on the surface contribute only indirectly to production.

The average value of the coal produced in Alabama in 1917 was $2.27 per ton, compared with $1.39 in 1916, an increase that was shared by all producing counties. The average value of all shipments was $2.19 per ton; of coal sold locally, $2.01 per ton; of mine fuel $2.08 per ton; and of coal made into coke at the mines, $2.71 per ton.

Coal Produced in Alabama in 1916 and 1917.

1916

COUNTY.	Loaded at mines for shipment (net tons).	Sold to local trade and used by employees (net tons)	Used at mines for steam and heat (net tons).	Made into coke at mines (net tons).	Total quantity (net tons).	Number of employees.			Average number of days worked.
						Underground.	Surface.	Total	
Bibb	1,384,205	12,281	97,370	———	1,493,856	2,142	411	2,553	255
Blount & Jackson	207,986	2,875	1,250	———	212,111	339	86	425	240
Etowah	154,474	2,163	1,964	———	158,601	281	54	335	269
Jefferson	7,428,469	303,661	268,133	1,834,606	9,834,869	10,869	1,793	12,662	275
Marion	68,083	6,021	6,054	———	80,158	180	41	221	215
St. Clair	765,485	3,403	23,282	———	792,170	787	110	897	250
Shelby	578,551	9,705	30,382	———	618,638	938	204	1,142	270
Tuscaloosa	272,307	8,859	59,270	600,360	940,796	1,042	240	1,282	293
Walker	3,540,791	40,744	99,506	250,982	3,932,023	4,739	955	5,694	235
Winston	22,005	410	———	———	22,415	86	11	97	143
Small mines	———	560	———	———	560	———	———	———	———
	14,422,356	390,682	587,211	2,685,948	18,086,197	21,453	3,855	25,308	262

*Includes Jackson County.

Coal produced in Alabama in 1917.

1917

COUNTY.	Loaded at mines for shipment (net tons).	Sold to local trade and used by employees (net tons)	Used at mines for steam and heat (net tons).	Made into coke at mines (net tons).	Total quantity (net tons).	Number of employees.			Average number of days worked.
						Underground.	Surface.	Total.	
Bibb	1,514,154	12,358	98,111	———	1,624,623	1,999	547	2,546	277
Blount	257,159	3,700	5,870	———	266,729	423	122	545	206
Etowah	150,153	1,918	2,194	———	154,265	197	41	238	271
Jefferson	7,089,174	229,060	300,555	2,834,304	10,453,093	11,746	2,731	14,477	291
St. Clair	813,070	3,406	20,519	———	836,995	643	91	734	290
Shelby	731,082	6,847	43,929	———	781,858	1,161	309	1,470	256
Tuscaloosa	193,800	87,528	36,642	605,765	923,735	1,227	315	1,542	240
Walker	4,364,113	151,560	123,649	205,158	4,844,480	5,170	1,193	6,363	243
Winston	43,456	444	———	———	43,900	118	20	138	176
Other counties‡	116,555	3,111	10,264	———	129,930	241	92	333	223
Small mines	———	8,466	———	———	8,466	———	———	———	———
	15,272,716	508,398	641,733	3,645,227	20,068,074	22,925	5,461	28,386	273

‡Includes Cullman, Jackson, and Marion counties.

Value of coal produced in Alabama in 1917.

COUNTY.	Loaded at mines for shipment.	Sold to local trade and used by employees.	Used at mines for steam and heat.	Made into coke at mines.	Total value.	Average value per ton.
Bibb	$3,669,103	$31,561	$224,880	—	$3,925,544	$2.42
Blount	659,832	9,300	16,748	—	685,880	2.57
Etowah	320,239	3,702	4,523	—	328,464	2.13
Jefferson	15,445,288	382,805	653,963	$8,167,903	24,649,959	2.36
St. Clair	1,560,721	6,764	30,320	—	1,597,805	1.91
Shelby	2,038,669	19,034	119,532	—	2,177,235	2.78
Tuscaloosa	453,778	190,742	68,182	1,234,479	1,947,181	2.11
Walker	8,786,741	347,490	198,182	470,145	9,802,558	2.02
Winston	124,307	1,100	—	—	125,407	2.86
Other counties*	332,817	7,851	15,525	—	356,193	2.74
Small mines	—	20,766	—	—	20,766	2.45
	33,391,495	1,021,115	1,331,855	9,872,527	45,616,992	2.27
Average value per ton	2.19	2.01	2.08	2.71	2.27	—

*Includes Cullman, Jackson, and Marion counties.

Coal produced in Alabama, 1913–1917, in net tons.

COUNTY.	1913	1914	1915	1916	1917	Increase or decrease, 1917.
Bibb	1,911,026	1,674,846	1,534,584	1,493,856	1,624,623	+130,767
Blount	178,958	150,384	165,739	†212,111	266,729	+ 54,618
Cullman, Jackson, and Marion	123,615	81,041	‡68,890	‡80,158	129,930	+ 49,772
Etowah	137,792	156,909	177,368	158,601	154,265	— 4,336
Jefferson	9,028,834	7,936,145	7,579,503	9,834,869	10,453,093	+618,224
St. Clair	890,379	752,588	774,058	792,170	836,995	+ 44,825
Shelby	497,569	498,914	589,412	618,638	781,858	+163,220
Tuscaloosa	917,305	858,899	787,586	940,796	923,735	— 17,061
Walker	3,967,263	3,450,185	3,221,955	3,932,023	4,844,480	+912,457
Winston	24,951	31,618	26,627	22,415	43,900	+ 21,485
Small mines	830	1,893	†2,265	560	8,466	+ 7,906
	17,678,522	15,593,422	14,927,937	18,086,197	20,068,074	+1,981,877
Total value	$23,083,724	$20,849,919	$19,066,043	$24,859,831	$45,616,992	+$20,757,161

†Includes Jackson county. ‡Marion county only.

LABOR STATISTICS.

Men employed in the coal mines of Alabama, 1917.

Underground	22,925
Surface	5,461
Total	28,386

Statistics of labor employed in coal mines of Alabama, 1908–1917.

YEAR	Number of days active.	Average Number Employed.
1908	222	19,197
1910	249	22,210
1911	227	22,707
1912	245	22,613
1913	255	24,552
1914	226	24,042
1915	223	22,591
1916	262	25,308
1917	273	28,386

Average production per man compared with hours worked per day, and average number of days worked 1910–1917.

Year	8 hours		9 hours		10 hours		All others	Total		Average Tonnage	
	Mines	Men	Mines	Men	Mines	Men	Men	Men	Days Worked	Per Year	Per Day
1910	18	766	36	2,633	184	17,306	1,525	22,230	249	725	2.91
1911	15	550	50	5,345	102	12,628	4,184	22,707	227	662	2.92
1912	11	338	46	4,145	107	13,938	4,192	22,613	245	712	2.91
1913	13	420	36	2,496	135	18,185	3,451	24,552	255	720	2.82
1914	14	646	24	3,546	150	18,115	1,735	24,042	226	648	2.87
1915	13	369	44	4,402	133	17,109	711	22,591	223	661	2.96
1916	9	306	40	2,724	182	20,786	1,902	25,308	262	715	2.73
1917	33	3586	27	1,900	143	20,766	2,184	28,386	273	707	2.59

Strikes and Suspensions.

Statistics of labor strikes in the coal mines of Alabama in 1916 and 1917.

1916			1917		
Number of men on strike	Total days lost	Average number of days lost per man	Number of men on strike	Total days lost	Average number of days lost per man
300	920	3	1835	10220	6

MINING METHODS.

The term "mining method" as used here refers to the manner in which the coal is broken down in the mine and not to the system of mining, or by room and pillar or long wall. In the mine the coal is either blasted from a solid face—shot from the solid—as in hard-rock mining, or is shot loose or otherwise broken down after a preliminary cut into the coal has been made. This cut may be made by hand or machine. Underground methods are therefore classified as shot from the solid, mined by hand, and mined by machines. An increasing quantity of coal is being recovered each year by stripping the cover from the bed in open pits by steam shovels. The bed thus exposed is for the most part shattered by powder and shoveled into cars by hand, although in places it is picked up directly by small steam shovels.

Opposition to shooting from the solid has developed, because it is injurious to the mining property in that the unusual charges of powder weaken the roof and pillars, which increases the liability to falls of roofs and coal, the most prolific cause of fatal accidents to coal miners. Another objection to this method is that the heavy charges of powder required to blow down the coal where it has not been previously undercut or sheared cause the production of a very high proportion of fine coal and render the lump coal so friable that it disintegrates in handling and in transportation. With the growing use of mechanical stokers and of powdered coal the latter objection is losing much of its force, but the danger attending the method has been in no wise diminished, and it is forbidden by law in some of the coal-mining states. There was a slight increase in the total output shot from the solid in 1916 compared with 1915.

Statistics of bituminous coal recovered from steam shovel pits, appear for the first time in 1916. One shovel only was active in Alabama in 1915.

Quantity and percentage of coal mined by different methods in Alabama in 1916 and 1917, in short tons.

YEAR	Mined by hand	Percentage	Shot off the solid	Percentage	Mined by machines	Percentage	From steam shovel pits	Percentage	Not reported	Percentage	Total production
1916	5,658,300	31.3	6,547,225	36.2	5,802,150	32.1	75,462	0.4	3,060	—	18,086,197
1917	5,340,112	26.6	8,419,146	42.0	6,062,744	30.1	231,217	1.2	14,855	0.1	20,068,074

Bituminous coal mined by machines in Alabama in 1916 and 1917.

YEAR	Number of machines in use	Number of tons mined by machines	Total tonnage of Alabama	Percentage of total product mined by machines
1916	320	5,802,150	18,086,197	32.1
1917	332	6,062,744	20,068,074	30.1

COAL-WASHING OPERATIONS.

Not all coal can be cleaned by hand picking. Some coal beds or parts of beds have layers or benches of slate and bone or contain more than the allowable quantity of sulphur in the form of iron pyrite so thoroughly mixed with the coal that crushing is necessary to free the coal from the refuse. To clear such coal washing is resorted to and the coal, being lighter than the refuse, is separated by currents of water. Coal is also cleaned in the dry state.

Strikes and Suspensions.

Statistics of labor strikes in the coal mines of Alabama in 1916 and 1917.

1916			1917		
Number of men on strike	Total days lost	Average number of days lost per man	Number of men on strike	Total days lost	Average number of days lost per man
800	920	8	1835	10220	6

MINING METHODS.

The term "mining method" as used here refers to the manner in which the coal is broken down in the mine and not to the system of mining, or by room and pillar or long wall. In the mine the coal is either blasted from a solid face—shot from the solid—as in hard-rock mining, or is shot loose or otherwise broken down after a preliminary cut into the coal has been made. This cut may be made by hand or machine. Underground methods are therefore classified as shot from the solid, mined by hand, and mined by machines. An increasing quantity of coal is being recovered each year by stripping the cover from the bed in open pits by steam shovels. The bed thus exposed is for the most part shattered by powder and shoveled into cars by hand, although in places it is picked up directly by small steam shovels.

Opposition to shooting from the solid has developed, because it is injurious to the mining property in that the unusual charges of powder weaken the roof and pillars, which increases the liability to falls of roofs and coal, the most prolific cause of fatal accidents to coal miners. Another objection to this method is that the heavy charges of powder required to blow down the coal where it has not been previously undercut or sheared cause the production of a very high proportion of fine c [illegible] der the lump coal so friable that it disintegr [illegible] ng and in transportation. With the growing [illegible] nical stokers and of powdered coal the la [illegible] is iosing much of its force, but the danger attending the method has been in no wise diminished, and it is forbidden by law in some of the coal-mining states. There was a slight increase in the total output shot from the solid in 1916 compared with 1915.

Statistics of bituminous coal recovered from steam shovel pits, appear for the first time in 1916. One shovel only was active in Alabama in 1915.

Quantity and percentage of coal mined by different methods in Alabama in 1916 and 1917, in short tons.

YEAR	Mined by hand	Percentage	Shot off the solid	Percentage	Mined by machines	Percentage	From steam shovel pits	Percentage	Not reported	Percentage	Total production
1916	5,658,300	31.3	6,547,225	36.2	5,802,150	32.1	75,462	0.4	3,060	—	18,086,197
1917	5,340,112	26.6	8,419,146	42.0	6,062,744	30.1	231,217	1.2	14,855	0.1	20,068,074

Bituminous coal mined by machines in Alabama in 1916 and 1917.

YEAR	Number of machines in use	Number of tons mined by machines	Total tonnage of Alabama	Percentage of total product mined by machines
1916	320	5,802,150	18,086,197	32.1
1917	332	6,062,744	20,068,074	30.1

COAL-WASHING OPERATIONS.

Not all coal can be cleaned by hand picking. Some coal beds or parts of beds have layers or benches of slate and bone or contain more than the allowable quantity of sulphur in the form of iron pyrite so thoroughly mixed with the coal that crushing is necessary to free the coal from the refuse. To clear such coal washing is resorted to and the coal, being lighter than the refuse, is separated by currents of water. Coal is also cleaned in the dry state.

Alabama leads in the quantity of coal washed, almost 44 per cent of the total quantity, so treated in 1917, being from the State.

Coal washed at the mines in Alabama in 1916 and 1917, with quantity of washed coal and of refuse obtained from it, short tons.

YEAR	Quantity of coal washed	Quantity of cleaned coal	Quantity of refuse	Percentage of cleaned coal to total state output
1916	10,695,700	9,742,467	953,233	53.9
1917	12,714,868	11,408,051	1,306,817	56.8

AVERAGE VALUE OF ALABAMA COAL.

Average value per short ton for coal at the mines in Alabama since 1908.

1908	1909	1910	1911	1912	1913	1914	1915	1916	1917
$1.26	$1.19	$1.26	$1.27	$1.29	$1.31	$1.34	$1.28	$1.37	$2.27

DISTRIBUTION AND CONSUMPTION.

C. E. LESHER.

OBJECT AND SCOPE OF REPORT.

THE object of this report is to furnish statistics showing the internal distribution of the coal produced in the United States, the principal purposes for which it is used, and the quantities consumed in each State. For 34 years the Geological Survey has collected and published the statistics of the production and value of coal, but this is the first comprehensive investigation made to show in detail where the coal produced is consumed. The competition between the bituminous coal-producing districts in the United States for the domestic markets is as active as that between the coal-exporting nations of the world for the foreign markets. The extent and nature of the demand in the domestic markets are moreover of ever-present interest to our coal industry, because more than 95 per cent of the coal produced in the United States is used within the country.

The largest problem confronting the exploiters of a coal deposit is, of course, that of markets, and whoever produces or sells the coal must consider in a broad way the possible markets not only as to quantity but as to quality. For blacksmithing and for making coal gas, coals that have special chemical properties are required, and domestic users have established preferences based on both experience and prejudice. By far the largest part of the coal supplied to every market is used for raising steam, and the statistics of coal used for this purpose in any and every part of the country are therefore of primary interest to those who are engaged in the coal industry. The limitations of time and funds available for the work on this report have permitted only incidental consideration of the markets for bituminous coals of particular kinds. The distribution of coal from West Virginia, for instance, is shown for the State as a unit, though there is a great difference between the kinds of coal mined there and as great a difference between the markets reached by the coal.

The cost of mining, the largest element of which—the cost of labor—is now practically controlled either directly or indirectly by the labor unions, and the cost of transportation, regulated by the Government through the Interstate Commerce Commission, impose definite limitations upon the markets that may profitably be reached by any coal. It is fast becoming the rule that the deciding factor in the purchase of coal for most uses is its cost in terms of the work to be performed.

Statistics of the movement of coal to market are of particular interest to those who are considering railroad rates. The quantity of coal carried by the railroads is larger than that of any other single commodity, and it is the coal traffic that has made possible the profitable operation of a number of important railroads. It is to the interest of the coal-carrying roads, within the limits of fair play, to keep in balance the movement from the competing fields. Here, again, data of the kind given in this report are needed as a basis of intelligent action.

The report of the Geological Survey on the distribution and consumption of coal in 1915, the first attempt to present such detailed statistics, was so generally well received and appeared to fill such a timely need that it was hoped to continue the statistics for succeeding years. The work of supplying the demand for statistics of coal and coke that followed the entrance of the United States into the war, in April, 1917, was so heavy that it precluded any attempt to compile data on distribution and consumption for 1916. The advent of the United States Fuel Administration, late in 1917, with its demand for statistical information, presented a special need and afforded a means of comprehensive study of the statistics of distribution for 1917. The particular need for these data by the Fuel Administration was connected with the proposed alloment of bituminous coal from producing districts to consuming States, and the zone system of distribution. The work of compilation was undertaken by the writer in his capacity of geologist in charge of coal statistics for the Geological Survey and director of the bureau of statistics of the Fuel Administration. The data originally compiled in the early months of 1918 have all been rechecked and are presented as nearly as possible in the form of the report for 1915.

Complete and absolutely accurate reports of distribution are impossible to obtain and any attempt to compile such statistics as this report contains must include estimates, but it is believed that these data in all important respects are accurate and that some of the shortcomings of the statistics for 1915 have been overcome.

DISTRIBUTION OF COAL PRODUCED IN ALABAMA IN 1917.

IN ITS output of coal Alabama is the most productive State in the South, and it is centrally located as regards the markets of the Southern States. In 1917 the Southern railroads used nearly 6,000,000 tons of Alabama coal, which is 28 per cent of the production in Alabama and nearly 20 per cent of the consumption by the railroads in the South. In addition to that taken by the railroads, more than 11,200,000 tons, or more than half the total output, was used in the State; 2,600,000 tons, or 13 per cent of the output, was shipped to other States; and 580,000 tons, or 3 per cent, went to tidewater for foreign and domestic cargo and bunker fuel. Of the coal shipped outside the State for commercial use the greater part, about 1,675,000 tons, reached the Mississippi Valley markets in Louisiana and Mississippi and in a less amount those in Missouri, Tennessee, and Arkansas. On the east, Georgia and Florida are the best consumers of Alabama coal.

Competition by coal from the fields to the north, particularly those of southern Illinois and western Kentucky, restricts the expansion of markets for coal from Alabama in the Mississippi Valley and at New Orleans. Similar competition on the east by coal from Virginia, Kentucky, and Tennessee meets coal from Alabama in the markets of the Carolinas and Georgia. The higher grades of Alabama coal are sent in small shipments to markets as distant as the Pacific coast. The tidewater business at southern Atlantic ports (except Hampton Roads) and at Gulf ports is not very large as compared with that at the northern ports, and in 1917 it was below normal. About 580,000 tons of coal from Alabama reached tidewater in 1917.

Distribution of bituminous coal produced in Alabama, 1917, by routes and destination.

STATE	All-rail shipments.						Shipped to tidewater.		
	Used within the State		Shipped to other States		Used by railroads.				
	Quantity (net tons)	Percentage of production.	Quantity (net tons)	Percentage of production.	Quantity (net tons)	Percentage of production.	Quantity (net tons)	Percentage of production.	Total quantity (net tons)
Alabama	11,222,916	56	2,622,000	13	5,641,254	28	581,904	3	20,068,074

The greater part of the coal produced in Alabama is used within the State or is taken by railroads in the South. Shipments to neighboring states represented in 1917 only 13 per cent and shipments to tidewater only 3 per cent of the total output.

Distribution of coal mined in Alabama in 1917.

	Quantity (net tons)	Percentage of total
Used in Alabama:		
Used at mines for steam and heat	641,733	
Sold to local trade, not shipped	508,398	
Made into coke at the mines*	3,645,227	
Shipped to Alabama	6,427,558	
	11,222,916	55.9
Shipped to other States by rail:		
Arkansas	15,000	
Florida	115,000	
Georgia	585,000	
Louisiana	925,000	
Mississippi	750,000	
Missouri	7,000	
Tennessee	175,000	
Texas	50,000	
	2,622,000	13.1
Used by railroads, all-rail delivery	5,641,254	28.1
Shipped to tidewater	581,904	2.9
	20,068,074	100.0

*Includes 2,127,000 tons shipped to beehive coke ovens.

South Atlantic and Gulf ports.

Originating field	Cargo, foreign	Bunker		Total
		Foreign	Coastwise	
Alabama	49,896	378,101	153,907	581,904

CONSUMPTION.

Bituminous coal of domestic origin consumed in Alabama, 1917, in net tons.

(Railroad fuel and bunker fuel for ocean vessels not included in this table.)

STATE	Used at mines for steam and heat.	Used in manufacture of beehive coke.	Used in manufacture of by-product coke.	Used in manufacture of coal and gas.	Used by electrical utilities.	Used for domestic purposes.	Used for industrial purposes.	Total coal consumed.
Alabama	641,733	3,658,598	3,980,243	90,886	299,966	651,000	2,131,490	11,453,916

Coal consumed in Alabama in 1917, according to source.

(Exclusive of fuel for railroads and steamships.)

SOURCE	Quantity net tons
Alabama	11,222,916
Kentucky	150,000
Tennessee	66,000
Virginia	15,000
Total bituminous coal	11,453,916
Pennsylvania anthracite	1,084
Total	11,455,000

Shipments by rail and water.

RAILROAD	Tons
Alabama Central	74,464
Atlanta, Birmingham & Atlantic	185,297
Birmingham Southern	3,144,419
Central of Georgia	767,618
Illinois Central	116,864
Louisville & Nashville	3,555,390
Mary Lee	21,190

Mobile & Ohio	**326,382**
Nashville, Chattanooga & St. Louis	**18,037**
St. Louis–San Francisco	**2,293,246**
Seaboard Air Line	**45,452**
Southern	**4,017,868**
Thomas & Sayreton	**476,467**
Woodstock & Blocton	**101,730**
Woodward Iron Co. Railorad	**60,347**
WATER	
Warrior River	**67,945**
Grand total	**15,272,716**

COKE.

PRODUCTION AND CONSUMPTION.

The production of coke in Alabama in 1880, 1890, 1900 and annually from 1910 to 1917 is shown in the following tables:*

Statistics of the manufacture of coke in Alabama, 1880–1917.

YEAR	Establishments	OVENS		Coal used (short tons)	Yield of coal in coke (per cent)	Coke produced (short tons)	Total value of coke at ovens	Value of coke at ovens, per ton
		Built	Building					
1880	4	316	100	106,283	57.0	60,781	$ 183,063	$3.01
1890	20	4,805	371	1,809,964	59.0	1,072,942	2,589,447	2.41
1900	30	6,529	690	3,582,547	58.9	2,110,837	5,629,423	2.67
1910	43	10,132	340	5,272,822	61.6	3,249,027	9,165,821	2.82
1911	44	10,121	280	4,411,298	62.6	2,761,521	7,598,594	2.75
1912	46	10,208	100	4,585,498	64.9	2,975,489	8,098,412	2.72
1913	46	10,284	20	5,218,323	63.6	3,323,664	9,627,170	2.90
1914	38	9,318	0	4,678,196	65.9	3,084,149	8,408,443	2.73
1915	38	9,318	0	4,695,938	65.4	3,071,811	8,545,555	2.78
1916	—	*9,549	97	6,794,100	57.9	4,298,417	15,019,187	3.45
1917	—	9,660	0	7,638,841	63.9	4,892,583	28,394,272	5.80

*Includes 300 Semet–Solvay, 487 Koppers, and 60 Wilputte ovens.

Comparison of the production and value of coke in Alabama in 1916 and 1917.

	Number of ovens	Coal charged (short tons)	Coke produced (short tons)	Total value of coke at ovens	Percentage of total U. S. value
1916	9,549	6,794,100	4,298,417	$15,019,189	7.9
1917	9,660	7,638,841	4,892,589	21,394,212	8.8
Increase	11	844,741	594,172	13,375,133	——
Percentage	0.1	12.4	13.8	33.3	——

†All the coke produced in Alabama is made from Alabama coal.

Coke produced in beehive and by-product coke ovens in Alabama, 1915–1917.

BEE-HIVE COKE					BY-PRODUCT COKE					TOTAL			
Active ovens.	Coal used (net tons)	Average yield (per cent).	Coke produced (net tons)	Value of coke at ovens.	Active ovens.	Coal used (net tons)	Average yield (per cent).	Coke produced (net tons)	Value of coke at ovens.	Coal used net tons)	Coke produced (net tons)	Percentage to total U. S. production.	Value of coke at ovens.
1915													
2,506	1,708,228	58.6	1,001,477	$3,086,656	732	2,987,710	69.3	2,070,334	$5,458,899	4,695,938	3,071,811	7.4	$8,545,555
1916													
4,269	3,158,417	57.9	1,828,067	$5,828,057	730	3,635,683	67.9	2,470,350	$9,191,082	6,794,100	4,298,417	7.9	$15,019,139
1917													
5,493	3,658,598	58.8	2,151,828	$12,138,161	331	3,980,243	68.9	2,740,761	$16,256,111	7,638,841	4,892,589	8.8	$28,394,272

Table showing increase of 1917 over 1916.

YEAR	BEEHIVE COKE				BY-PRODUCT COKE				TOTAL		
	Active ovens	Coal used (net tons)	Coke produced (net tons)	Value of coke at ovens	Active ovens	Coal used (net tons)	Coke produced (net tons)	Value of coke at ovens	Coal used (net tons)	Coke produced (net tons)	Value of coke at ovens
1916	4,269	3,158,417	1,828,067	$5,828,057	730	3,635,683	2,470,350	$9,191,082	6,794,100	4,298,417	$15,019,139
1917	5,493	3,658,598	2,151,828	12,138,161	831	3,980,243	2,740,761	16,256,111	7,638,841	4,892,589	28,394,272
Increase	1,224	500,181	323,761	6,310,104	101	344,560	270,411	7,065,029	844,741	594,172	13,375,133
Percentage	27.7	16.4	17.7	108.3	13.7	9.5	11.0	76.8	12.4	13.8	89.1

VALUE.

Quantity (net tons) and value of coke produced in Alabama, 1912–1917.

	1912	1913	1914	1915	1916	1917	Increase	Percentage	
								Total	
Quan.	2,975,489	3,323,664	3,084,149	3,071,811	4,298,417	4,892,589	594,172	13.8	
Value	$8,098,412	$9,627,170	$8,408,443	$8,545,555	$15,019,139	$28,394,272	13,375,133	88.8	88.9

Average value, per short ton and percentage of coke from coal, in Alabama, 1911–1917.

	1911	1912	1913	1914	1915	1916	1917
Average value	$2.75	$2.72	$2.90	$2.73	$2.78	$3.49	$5.80
Percentage yield	62.6	64.9	63.6	65.9	65.4	63.3	63.9

Quantity and value of coal used in the manufacture of coke in Alabama in 1916 and 1917, and quantity and value of same per ton of coke.

YEAR	Coal used (short tons)	Total value of coal	Value of coal per ton	Quantity of coal per ton of coke (short tons)	Value of coal to a ton of coke
1916	6,794,100	$11,000,238	$1.62	1,581	$2,561
1917	7,638,841	18,776,218	2.46	1,561	3,840

COKE OVENS.

Coke ovens in Alabama, 1916 and 1917.

YEAR	Active		Idle		Total		Abandoned	
	Beehive	By-product	Beehive	By-product	Beehive	By-product	Beehive	By-product
1916	4,269	730	4,537	13	8,806	743	62	7
1917	5,493	831	3,320	16	8,813	847	1	

Coke ovens in Alabama at the end of 1911–1917

YEAR	Beehive	By-product
1911	9,781	340
1912	9,588	620
1913	9,584	700
1914	8,568	750
1915	8,568	750
1916	8,806	743
1917	8,813	847

Record of by-product ovens in Alabama, 1910–1917.

YEAR	Built	Building
December 31, 1910	280	340
December 31, 1911	340	280
December 31, 1912	620	100
December 31, 1913	700	20
December 31, 1914	750	0
December 31, 1915	750	0
December 31, 1916	743	97
December 31, 1917	847	0

By-product coke plants in Alabama in 1917.

Town	Name of company owning plant	Number of ovens	Type of oven	Year put in blast	Uses of coke	Uses of surplus gas	Benzol recovery plant
Ala. City	Gulf States Steel Co.	37	Koppers	1917	Blast furnace	Industrial fuel	Yes
Ensley	Tennessee Coal, Iron & R. R. Co.	240	Semet-Solvay	1898–1902	Blast furnace	Boiler fuel	Yes
Fairfield	Tennessee Coal, Iron & R. R. Co.	280	Koppers	1912	Blast furnace	Industrial fuel	Yes
Tuscaloosa	Central Iron & Coal Co.	60	Semet-Solvay	1906–1914	Furnace, foundry, and heating	Boiler fuel	Yes
Woodward	Woodward Iron Co.	170	Koppers	1911–1914	Blast furnace	Industrial fuel	Yes
Woodward	Woodward Iron Co.	60	Wilputte	1917*		Industrial fuel	Yes

*1917—Additional benzol recovery plant operated by Thomas A. Edison.

CHARACTER OF THE COAL USED.

Ninety-four and two-tenths per cent of the coal used in the manufacture of coke in Alabama is washed before being charged into the ovens. In 1917, out of a total of 7,638,841 tons of coal made into coke, 7,193,146 tons were washed. Of the washed coal used 2,964,789 tons were slack, and 4,228,357 tons were mine run.

The unwashed mine run coal was 445,695 tons, while there was none of the slack unwashed.

The character of the coal used in the manufacture of coke in Alabama in 1890, 1900, and for the last eight years, is shown in the following tables:

Character of coal used in the manufacture of coke in Alabama, 1890–1917, in short tons.

YEAR	Run of Mine		Slack		Total
	Unwashed	Washed	Unwashed	Washed	
1890	1,480,669	0	206,106	128,189	1,809,964
1900	1,729,882	152,077	165,418	1,535,170	3,582,547
1910	771,981	1,308,085	0	3,192,306	5,272,322
1911	693,185	1,295,109	2,937	2,420,117	4,411,298
1912	747,305	896,421	18,793	2,922,979	4,585,498
1913	868,659	684,223	0	3,665,441	5,218,323
1914	703,241	2,069,638	0	1,905,317	4,678,196
1915	158,480	1,522,149	47,061	2,968,248	4,695,938
1916	238,849	2,352,907	0	4,202,344	6,794,100
1917	445,695	4,228,357	0	2,964,789	7,638,841

Character of coal used in the manufacture of coke in Alabama in 1914, 1915, 1916 and 1917, in short tons.

Year	Run of mine		Slack		Total			
	Unwashed	Washed	Unwashed	Washed	Unwashed	Percentage	Washed	Percentage
1914	703,241	2,069,638	0	1,905,317	703,241	15.0	3,974,955	85.0
1915	158,480	1,522,149	47,061	2,968,248	205,541	4.4	4,490,397	95.6
1916	238,849	2,352,907	0	4,202,344	238,849	3.5	6,555,251	96.5
1917	445,695	4,228,357	0	2,964,789	445,695	5.8	7,193,146	94.2

RANK OF THE STATES IN COKE PRODUCTION.

Coke was produced in 1917 in 22 states; in 5 only beehive coke was made. In the other states either the whole product came from by-product ovens, or both methods of coke-making were employed. In total output Pennsylvania heads the list, with Alabama, Ohio, Indiana, and West Virginia following in order. As regards the production of coke from by-product ovens the first five states rank Pennsylvania, Ohio, Indiana, Alabama, Illinois, while West Virginia ranks as No. 12.

The rank of the coke-producing states in respect of the total and of by-product output for the years 1913-1917 is shown in the following table:

Rank of the States in the production of coke, 1913–1917.

STATE	1913		1914		1915		1916		1917	
	Total	By-product	Total	By-product	Total	By-product	Total	By-product	Total	By-product
Pennsylvania	1	1	1	1	1	1	1	1	1	1
Alabama	2	3	2	3	2	3	2	3	2	4
Ohio	14	11	11	9	7	7	6	5	3	2
Indiana	3	2	3	2	3	2	3	2	4	3
West Virginia	4	12	5	14	5	13	4	15	5	12
Illinois	5	4	4	4	4	4	5	4	6	5
Virginia	6	—	6	—	10	—	7	—	7	—
Colorado	7	—	7	—	9	—	8	—	8	—
New York	8	5	12	8	8	6	11	7	9	6
Wisconsin	9	6	8	5	11	8	12	8	10	7
Michigan	11	8	9	6	6	5	10	6	11	8
Kentucky	16	14	13	11	12	12	9	12	12	10
Massachusetts	10	7	10	7	13	9	13	9	13	9
New Mexico	12	—	14	—	14	—	14	—	14	—
Maryland	18	10	19	13	16	10	15	10	15	11
Minnesota	19	13	18	12	21	15	16	11	16	13
New Jersey	17	9	17	10	17	11	20	14	17	14
Tennessee	13	—	16	—	18	17	18	16	18	16
Utah	15	—	15	—	15	—	17	—	19	—
Missouri	—	—	—	—	20	14	19	13	20	15
Washington	20	—	20	15	19	16	21	17	21	17
Georgia	21	—	21	—	22	—	22	—	22	—

DISTRIBUTION.

Beehive coke shipped by originating railroads and waterways in Alabama in 1917.

RAILROAD	Shipments (net tons)	Production (net tons)	Percent. of production
Louisville & Nashville	615,906	——	——
Southern	496,026	——	——
Birmingham Southern: Ala. and Georgia	291,233	——	——
Total	1,403,165	2,151,828	65.2

Coke produced in individual States in 1916, in net tons.

ALABAMA

DESTINATION.	Furnace	Foundry	Domestic fuel, and other kinds.	Export
Alabama	4,048,471	157,328	398	——
Arizona and Colorado	——	184	4,204	——
•Arkansas, Kansas and Oklahoma	——	762	200	——
California	——	3,479	——	——
Florida	155	1,274	72	——
Georgia	——	13,411	581	——
Illinois, Indiana and Virginia	——	236	121	——
Kentucky	——	50	——	——
Louisiana	231	41,178	586	——
Mississippi	——	1,763	662	——
Missouri	——	5,021	96	——
North and South Carolina	——	175	——	——
Oregon	——	126	——	——
Tennessee	——	24,609	671	——
Texas	1,444	16,256	3,827	——
Total	4,050,301	265,842	11,418	14,984

CONSUMPTION.

Coke consumed in Alabama, exclusive of imports, in net tons.

YEAR	Furnace	Foundry	Dom. fuel and other kinds
1915	2,870,378	110,901	.....
1916	4,048,471	158,339	747

Coke consumed in Alabama in 1916, in net tons.

SOURCE	Furnace	Foundry	Dom. fuel and other kinds
Alabama	4,048,471	157,323	393
Georgia, Tennessee, Virginia and West Va.	———	1,016	354
	4,048,471	158,339	747

Coke produced in Alabama in 1916 by uses, in net tons.

Furnace	Foundry	Domestic fuel and other uses	Exports	In (+) or out (—) of stock piles	Total production
4,050,301	265,842	11,418	14,984	—44,123	4,298,417

BY-PRODUCTS OBTAINED IN THE MANUFACTURE OF COKE.

1916.—The recovery of the valuable by-products obtainable from American coke ovens continued to make important gains in 1916. The quantities of by-products obtained increased approximately in ratio with the increase in the output of by-product coke, with the exception of the benzol products, which showed gains ranging in round figures from 400 to 1,800 per cent. The value of these benzol products amounted to $30,000,000 in 1916, compared with $7,340,000 in 1915 and less than $1,000,000 in 1914, whereas the total value of all by-products obtained rose from $30,000,000 in 1915 to $62,000,000 in 1916.

Under the stimulus of war prices the number of plants equipped for benzol recovery increased from 30 in 1915 to 39 at the end of 1916. The benzol products obtained in 1916 amountel to 43,709,779 gallons. More than 16,500,000 gallons of the output was reported as crude light oil, with an average value of 30 cents a gallon. An increasingly large number of by-product plants operated their own refineries, and the output of pure benzol reported in 1916 from these sources increased nearly 750 per cent over the figures for 1915 and amounted to 21,079,500 gallons, with an average value of more than 62 cents a gallon. Similarly the reported production of toluol gained more than 500 per cent and amounted to 3,939,636 gallons in 1916, with an average value of slightly more than $2.85 a gallon.

Approximately 185,500,000 gallons of tar was obtained from by-product coke ovens in 1916, the value of which was $4,865,921.

The output in 1916 of ammonia, of which about 135,000 tons was reported as sulphate, 3,224,718 gallons as liquor, and 47,739,602 pounds as anhydrous ammonia, was equivalent to a total of 470,530,547 pounds of ammonium sulphate and had a value of $14,152,243. Surplus gas, amounting to 110,062,000,000 cubic feet and valued at $10,779,208 was sold or used, of which 20,552,000,000 feet was used as illuminating gas, 6,558,000,000 feet as domestic fuel, and 82,951,000,000 feet as fuel for raising steam for open-hearth furnaces in gas engines and for other industrial purposes. These by-products, which had a total value of $61,931,595, were obtained by the carbonization of 26,524,502 net tons of coal, from which was also obtained 19,069,361 tons of coke, valued at $75,373,070. The total value of the output of coke and by-products in 1916 was more than $137,300,000, compared with $78,300,000 in 1915.

1917.—Increased quantities of by-products were recovered from coke plants in 1917, the gain paralleling the continued expansion of the whole by-product coke industry. Benzol products remained the feature of greatest interest, and the number of plants equipped for their recovery rose from 39 in 1916 to 47 in 1917. Late in

1917 all toluol was commandeered by the War Department, and prices were set at a figure much below the prevailing market rates by a voluntary agreement between the Government and the toluol producers. In conseequence, the aggregate value of these products declined from $30,000,000 in 1916 to $28,500,C00 in 1917, although production increased nearly 25 per cent, the total volume of benzol products amounting to 54,387,266 gallons in 1917.

Additional plants were equipped for refining their light oil fractions, with the result that the quantity of crude light oil reported for 1917 was only about 7,500,000 gallons, compared with 16,500,000 gallons in 1916, while pure benzol reported from these sources increased from 21,000,000 gallons in 1916 to nearly 37,000,000 gallons in 1917, with an average value per gallon for the latter of 45 cents. Nearly twice as much toluol (7,395,174 gallons) was produced at by-product plans in 1917 as in 1916. Because of the price agreement with the Government, the average value per gallon of toluol was $1.37 in 17917, compared with $2.85 in 1916.

Tar obtained from by-product ovens amounted to 221,999,264 gallons in 1917, valued at $5,566,302.

The output of ammonia in 1917, equivalent to 560,792,322 pounds of ammonium sulphate, had a value of $17,903,864.

Surplus gas, amounting to 131,027,000,000 cubic feet, and valued at $11,360,335, was sold or used in 1917, of which 21,289,000,000 feet was used for illuminating purposes, 7,271,000,000 feet was reported as domestic fuel, and 102,466,000,000 feet served as industrial fuel for open-hearth furnaces, in gas engines, and for other purposes.

By-products obtanied in 1917 had a total value of $67,670,679 and their production required the carbonization of 31,505,759 net tons of coal, from which was also obtained 22,439,280 net tons of coke valued at $138,643,153. The total value of the output of all by-product ovens in 1917 was more than $206,300,000, compared with $137,300,000 in 1916 and $78,300,000 in 1915.

The yield of coke per ton of coal in different plants ranged from 1,106 to 1,682 pounds. Several operators reported the recovery of more than 10 gallons of tar from 2,000 pounds of coal; one reported 13.5 gallons and one as little as 4.8 gallons. Twenty-one operators reported their ammonia entirely in the form of sulphate, and the average recovery in these operations was 19.85 pounds of sulphate per ton of coal. Twenty-three operators reported their ammonia as pounds of NH_3, with an average of 4.96 pounds of NH_3 recovered from each 2,000 pounds of coal. The other operators reported their ammonia either wholly or in part as liquor or as sulphate and NH_3. Individual operations showed average recovery ranging from 3.2 to 6.2 pounds of NH_3 and from 12.1 to 26.3 pounds of ammonium sulphate per ton of coal.

Some plants are not equipped for fractionating the oils of the benzol group, but ship their crude products to refineries or chemical works for further treatment, and for that reason part of these products were reported and are shown here as crude and secondary oils.

GRAPHITE.

By Henry G. Ferguson.

Introduction.

THE peculiar physical properties of graphite—infusibility, chemical inertness, high conductivity, extreme softness, and low specific gravity—fit it for many uses, such as the manufacture of crucibles and other refractory products, lubricants, lead pencils, paint, foundry facings, as a preparation to loosen boiler scale, as polish for gunpowder, and for various applications in electrical works.

Natural graphite may be either crystalline or amorphous. The term crystalline or flake graphite is commonly understood to mean graphite in crystals large enough to be visible to the naked eye; much of the so-called amorphous graphite shows a crystalline structure under the microscope. Crystalline graphite occurs either in veins, as in the Ceylon deposits, or as flakes disseminated through the country rock, as in most of the crystalline graphite deposits of the United States. Most deposits of amorphous graphite are the result of the alteration of coal beds by the intrusion of igneous rocks. Amorphous graphite is also made artificially by means of the electric furnace.

USES OF GRAPHITE.

By far the most important use of graphite is in the manufacture of crucibles, and for this reason graphite is a mineral resource of vital importance in time of war, and American producers of flake graphite have greatly increased their output. The makers of crucibles have also greatly increased their production during the last two years. Graphite for making crucibles must be of great purity. Its content of graphitic carbon should exceed 85 per cent and should preferably be as high as 90 per cent, and it must be practically free from mica, pyrite, and iron oxide. A small amount of quartz is not injurious. Graphite for making crucibles should also be coarse enough for the interlocking fragments to be easily bound together by the clay with which it is mixed. It should preferably contain a large proportion of flakes about 1 millimeter in diameter and should all remain on a 100-mesh sieve.

Most makers of crucibles prefer to use Ceylon graphite mixed with 10 to 25 per cent American flake in part because the more nearly cubical fragments of Ceylon graphite have a much smaller surface area in proportion to their volume than the thin flakes of the domestic graphite and hence require proportionately less clay as a binder. Ceylon graphite is also more nearly free from undesirable impurties such as mica and pyrite. It is possible, however, to use domestic flake graphite alone with good success in crucible manufacture. In recent commercial tests of crucibles made with Alabama flake graphite and domestic clay three No. 80 crucibles, tested in copper melting, gave 21 heats each, and a fourth 42 heats. There is, however, no immediate prospect of a sufficiently increased domestic production to supply the needs of crucible manufacturers, and graphite must still be imported from Ceylon or Madagascar, but it is believed that the percentage of domestic material used could be increased. The only American graphite resembling the Ceylon material is produced in small amount in Montana.

The difficulties encountered since 1914 in finding satisfactory supplies of clay have now been largely overcome, and the crucibles made with domestic clays are of much better grade than formerly. A part of the great demand for crucibles has been due to the fact that crucibles made with domestic clays did not stand as many heats as those made with the Bavarian clay and consequently a larger number were required to accomplish the same work. According to McNaughton,* the results attained in the early attempts to use domestic clays were very unsatisfactory. In certain tests only 4 or 5 heats were secured with crucibles of average size, as against 25 to 30 heats before the war. At present from 15 to 25 heats is the range of average service. The cost of the domestic clay, however, is more than double that of the German clay used prior to the war.

Graphite for other uses does not require the same grade of material as for crucibles, and for most purposes amorphous graphite can be used with as good effect as the crystalline variety. Graphite for foundry facings, commonly known as "silver lead," is of varying degrees of purity, according to the work required. Ceylon dust was formerly used to a considerable extent for this work, but the present high prices, due to the high freight rates, have greatly decreased its use. Next to crucibles, foundry facings probably absorb more graphite than any other single use.

Lubricating graphite must be of a high degree of purity and absolutely free from gritty substances, such as quartz. As size of grain is not essential, either amorphous or crystalline graphite may be used.

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*McNaughton, M., The crucible situation: Metal Industry, vol. 15, pp. 431-432, 1917.

For pencils either amorphous graphite alone or a blend of amorphous and fine-grained crystalline graphite is employed. The graphite is mixed with clay in varying proportions, according to the hardness desired. In order that the product shall be uniform, very pure graphite is required.

For other uses, such as fillers for dry batteries, facings for molds, polish for explosives, paints, boiler mixture, and many similar requirements, either crystalline or amorphous graphite may be used, and the degree of purity essential varies according to the nature of the use.

IMPORTS.

The following table shows the imports of graphite into this country since 1913. As the war has disarranged the usual trade routes and as the statistics of the Bureau of Foreign and Domestic Commerce necessarily show only the country from which shipments were made, it is necessary to draw some inferences as to the country of origin. Graphite entered in the import statistics as coming from France is probably all of Madagascar origin, and all graphite imported from Great Britain has been assigned to Ceylon. Similarly shipments from Japanese ports are assumed to represent Chosen graphite as the Japanese production is of minor importance. The imports from Canada in 1914 and 1915 were in excess of the Canadian production for these years, so it is probable that these imports include a certain amount of Ceylon material.

*Graphite imported into the United States, 1913–1917.**

COUNTRY EXPORTING	Probable country of origin	QUANTITY (SHORT TONS)					VALUE				
		1913	1914	1915	1916	1917	1913	1914	1915	1916	1917
Other British East Indies	Ceylon	16,996	8,374	12,275	24,411	24,304	$1,674,764	$920,147	$1,564,917	$5,846,515	$7,075,143
England	Ceylon	—	381	2,216	561	6	—	42,446	261,321	166,847	1,566
British India	Ceylon	—	127	—	1,260	265	—	9,815	—	343,170	102,499
Total, Ceylon		16,996	8,882	14,491	26,232	24,575	1,674,764	972,408	1,826,238	6,356,532	7,179,208
Netherlands	(?)	—	—	36	—	—	—	—	2,811	—	—
Dutch East Indies	(?)	—	—	—	169	—	—	—	—	21,484	—
Madagascar	Madagascar	—	155	36	—	—	—	18,426	2,831	—	—
France	Madagascar	—	194	1,432	1,631	4,393	—	20,278	181,236	241,863	1,057,081
Total, Madagascar		—	349	1,468	1,631	4,393	—	38,704	184,067	241,863	1,057,081
Canada	Canada	1,662	1,806	2,995	4,127	3,476	98,665	92,536	116,407	314,177	349,034
Brazil	Brazil	—	—	—	1	18	—	—	—	75	4,380
Mexico	Mexico	4,435	4,259	1,680	5,331	7,570	198,000	190,075	75,000	238,000	285,568
Chosen	Chosen	—	—	—	337	137	—	—	—	10,534	5,483
Japan	Chosen	4,170	6,327	2,373	5,038	2,314	58,199	96,433	35,292	93,085	77,652
Japanese China	Chosen	—	—	—	—	11	—	—	—	—	423
Total, Chosen		4,170	6,327	2,373	5,375	2,462	58,199	96,433	35,292	103,619	83,558
Italy	Italy	236	254	27	151	115	4,061	3,203	994	4,133	3,092
Austria	Bohemia	660	78	—	—	—	9,957	1,258	—	—	—
Germany	Bavaria	90	—	—	—	—	4,034	—	—	—	—
Other countries		630	47	5	—	—	62,111	3,644	354	—	67
Grand total		28,879	22,002	23,077	43,017	42,609	2,109,791	1,398,261	2,241,163	7,279,883	8,961,988

*Compiled from reports of the Department of Commerce.

DOMESTIC PRODUCTION.

CRYSTALLINE GRAPHITE.

The increase in metal manufacture incident to the progress of the war has brought a greatly increased demand for crucible graphite, and the amount of graphite suitable for crucible use, both domestic and imported, consumed during the year was approximately 30,000 short tons, as against 13,500 short tons in 1913. The domestic production has responded to the greater demand and during the last three years has shown a steady increase.

The actual mine production during 1917 has shown a notable gain. The total production, including stocks on hand at the mines, was approximately 14,000,000 pounds as against about 10,900,000 pounds in 1916. The figures for sales, however, which are used as the basis of the following tables, show a slight decrease. This is due principally to the facts that owing to the freight congestion the Alabama producers have had great difficulty in shipping their product and that many new companies have been unable to begin production owing to delay in procuring the necessary equipment. During the last three months of 1917 shipments of crystalline graphite from the Alabama field were only about 25 per cent of the capacity of the mills. The extremely severe winter also curtailed production, both in Alabama and in New York. In Pennsylvania the sharp decrease compared with 1916 is due to the remodeling of several of the larger plants. Many of the mills had large stocks on hand at the end of the year, but as the Survey's figures of production are based on sales, the amount of these stocks is not included in the total for the year.

Estimates furnished by the producers of crystalline graphite show that out of the total sales of 10,584,080 pounds, 6,816,913 pounds, valued at $982,336, or about 64 per cent by weight and 90 per cent by value of the total, was flake graphite containing from 80 to 90 per cent graphitic carbon, in large part suitable for crucible use. The remainder, 3,767,167 pounds, valued at $112,062, was dust or low-grade flake probably averaging under 50 per cent graphitic carbon. The proportion of flake produced is higher than in previous years, owing in part to improved milling methods, whereby a larger proportion of the graphite was saved as flake, and in part to the fact that because of the freight embargo during the later part of the year such shipments as the Alabama producers were able to make consisted mainly of the better-grade material.

As usual, the greater part of the domestic crystalline graphite was produced in Alabama, New York, and Pennsylvania. The production of these states was all of the variety known in the trade as flake graphite, which occurs as small flakes forming 3 to 10 per cent, by weight, of crystalline schists. In addition, crystalline graphite, resembling in a general way the Ceylon graphite, was produced in Montana, and a small quantity of flake graphite was mined in California and Texas. The quantity of crystalline graphite in 1917 was slightly less than the sales for the preceding year, but the value showed an increase of 20 per cent over 1916. The number of producers of crystalline graphite was 14 in Alabama, 1 in Alaska, 1 in California, 1 in Montana, 4 in New York, 5 in Pennsylvania, and 1 in Texas.

Crystalline graphite sold in the United States, 1916 and 1917.

	1916				1917	
					Total	
	Quantity (pounds)	Value	No. 1 and No. 2 flake (pounds)	Other grades (pounds)	Quantity (pounds)	Value
Alabama	5,226,940	$492,407	4,295,233	1,927,862	6,223,095	$719,575
New York	*	*	1,656,897	1,284,143	2,941,040	261,548
Pennsylvania	1,095,716	103,377	549,783	255,162	804,945	77,475
Other states†	4,609,333	318,964	315,000	300,000	615,000	35,800
	10,931,989	914,748	6,816,918	3,767,167	10,584,080	1,094,398

*Included in "Other States."

†1916: California, Montana, New York, and Texas; 1917: Alaska, California, Montana, and Texas.

AMORPHOUS GRAPHITE.

The production of amorphous graphite during 1917 was 8,301 tons, valued at $73,481, as compared with 2,622 tons, valued at $20,723 in 1916. As amorphous graphite is not suitable for use in crucible manufacture, war conditions have not increased the demand for it to so marked a degree as for crystalline graphite. Moreover, the production of flake graphite for crucible use yields a large amount of dust as a by-product, and this dust is available for practically all uses to which amorphous graphite can be put.

The better grades of amorphous graphite are imported from Mexico and Chosen, and the imports, like those of crystalline graphite, greatly exceed the domestic production. Artificial amorphous graphite is also a competitor of the natural product.

Amorphous graphite was produced by 6 mines in 1917, as against 5 in 1916. The producing states were Colorado, Michigan, Nevada, and Rhode Island. On account of the small number of producers, figures showing the production by states can not be published without disclosing individual returns.

ARTIFICIAL GRAPHITE.

Graphite is manufactured chiefly by the International Acheson Graphite Co., which utilizes electric power generated at Niagara Falls. The output has increased greatly in recent years and now forms an important element in the country's graphite supply. The bulk graphite is made either from anthracite or from petroleum coke and is utilized mainly in lubricants and paints and for foundry facings, boiler-scale preventives, and battery fillers.

Besides the graphite products that enter into competition with natural graphite, there are a large number for which artificial graphite is particularly adapted. Chief among these is graphite electrodes, the demand for which has greatly increased during the last three years on account of the remarkable growth in certain electrochemical industries.

MARKETS AND PRICES.

Domestic flake graphite brought slightly higher prices in 1917 than in 1916. The prices received at the mines for the best grades ranged from 12 to 18 cents a pound for No. 1 flake, according to its grade; from 6 to 10 cents a pound for Nos. 2 and 3; and from half a cent to 5 cents a pound for dust. Flake graphite containing 90 per cent or more of graphitic carbon sold for considerably higher prices than the usual product containing 85 per cent carbon or less. Prices reported by purchasers were, in general, from 12 to 17 cents a pound for No. 1 flake and occasionally prices as high as 20 cents a pound for special lots, 9½ to 12 cents for No. 2, and 1 cent to 9 cents for lower grades. Ceylon graphite was hard to obtain during the summer, and domestic flake was consequently in great demand, but in September large quantities of Ceylon graphite became available and the manufacturers no longer required the domestic product. This new supply, coupled with the difficulty of rail shipments, due to the freight embargoes, seriously affected the domestic industry.

The prices paid at the mines for the highest-grade domestic graphite have been as follows: 1911 and 1912, 6 to 7 cents a pound; 1913, 6 to 8 cents; 1914, 6½ to 8 cents; 1915, 7 to 10 cents; 1916, 10 to 16 cents; 1917, 12 to 18 cents.

Ceylon graphite of the better grades is more largely used by crucible makers than domestic flake graphite and even in normal times commands a higher price. During the last three years the tremendous increase in crucible manufacture has caused a demand for the Ceylon product greatly in excess of the available supply and the price has constantly increased. The sharp increase of price for all grades of Ceylon graphite in 1916 over that for previous years was due in part to the fact that a much larger proportion of the highest-grade product was imported. During 1917 the prices of Ceylon graphite in the eastern market were approximately as follows: Lump, 27 to 30 cents a pound; chip, 19 to 24 cents; dust, 7 to 14 cents, according to grade. These prices show only a slight increase over those for 1916.

Madagascar graphite is a flake graphite similar to the crystalline graphite produced in this country, but the flakes are larger and thicker. The prices during 1917 ranged from 11 to 14 cents a pound, or slightly lower than those for domestic graphite. The Mining Journal (London) since June 9, 1917, has given weekly quotations for Madagascar graphite based on 80 and 85 per cent carbon with an allowance of 15 francs per metric ton per unit of variation. These quotations showed a range in prices (f. o. b. Tamatave) of 900 to 950 francs per metric ton for 85 per cent material. During the later part of the year the price quoted was 1,250 francs f. o. b. Marseille for 80 per cent material, or about 10 cents a pound at prevailing exchange rates, and 900 francs f. o. b. Tamatave for 85 per cent, in each case with an allowance of 15 francs per unit of carbon variation. The average value of material imported into this country, as shown by the import figures of the Bureau of Foreign and Domestic Commerce, is 12.3 cents a pound.

The following table shows the average prices of Ceylon and Madagascar graphite imported into this country, as compiled from the records of the Bureau of Foregin and Domestic Commerce, and the average prices of all grades of domestic crystalline graphite, including both dust and flake, as reported by the producers. The sharp increase in the price of Ceylon graphite in 1916 appears to be due to the diminished import of lower-grade material as well as to enhanced prices for the better grades:

Average price of crystalline graphite, in cents a pound, 1912–1917.

	Ceylon	Madagascar	Domestic		Ceylon	Madagascar	Domestic
1912	4.1	——	4.2	1915	6.8	6.3	5.9
1913	4.9	——	5.0	1916	12.0	7.4	8.4
1914	5.5	5.5	5.5	1917	14.6	12.3	10.3

Domestic amorphous graphite brought widely varying prices, according to the grade of the material mined.

Although the demand was generally good, the prices do not appear to have increased greatly during the year.

Chosen amorphous graphite, which before the war sold at about $22 a ton, during 1917 brought from $45 to $60 a ton. The amount available was not as large as in former years, and the Chosen material appears to be in large measure supplanted by Mexican, domestic, and artificial amorphous graphite.

In order to assist producers in marketing their product, the Geological Survey has prepared a list of firms known to be purchasers of domestic graphite. This list will be mailed free on request to the Director, United States Geological Survey.

ALABAMA—GENERAL FEATURES.

The Alabama graphite mines in 1917 furnished approximately 59 per cent of the quantity and 66 per cent of the value of the domestic crystalline graphite sold—an increase of 19 per cent in quantity and 46 per cent in value over 1916, and 3 times the quantity and 8 times the value of Alabama's output in 1913. Sales were reported by 14 companies in 1917, and 25 others have begun operations since the beginning of 1918 or expect to begin in the near future. Work has been most active in the Ashland district in Clay County. The producing companies number 11 in Clay County, 2 in Coosa County, and 1 in Chilton County. In spite of the great increase in the number of companies only a comparatively small portion of the graphite-bearing area is yet under development, and for the most part the operations are confined to localities near the power lines of the Alabama Power Co.

The embargo on freight shipments during the later part of 1917 seriously affected the Alabama production, and many of the mines were unable to make shipments to the northern markets. During the last quarter of the year the production was only about 25 per cent of the maximum capacity of the mills. The principal reason for the shortage was the freight embargo, but the shortage of labor and the severe winter were also important factors.

The Alabama flake graphite from different mines varies greatly in purity, and lack of standardization hinders the full development of the deposits. A few companies produce a No. 1 flake containing 90 per cent carbon, others maintain an 85 per cent standard, and some market flake averaging only about 80 per cent.

The following analyses, furnished through the courtesy of one company, shows the content of the average grade of the Alabama product. No 1 represents samples from 5 tons and No. 2 from 3 tons of flake.

Analyses of Alabama flake graphite.

	1	2
Volatile matter	2.00	1.08
Carbon (graphitic)	84.00	84.72
Ash	14.00	14.20
	100.00	100.00
Iron	.97	
Sulphur	.08	

Ash analysis of sample 2.

	Ash	Percentage for entire product
Fe_2O_3	8.32	1.18
Al_2O_3	22.94	3.26
SiO_2	64.27	9.13
CaO	Trace	Trace
MgO	1.43	.20
S	.32	.05
Alkalies	2.78	.39
	100.06	14.21

The ash analysis indicates that the principal foreign impurity in the finished product is silica, with a little clayey matter, very little mica, and almost no pyrite.

The graphite occurs in a graphitic schist which forms lenses in a series of metamorphic rocks traversing parts of Clay, Coosa, and Chilton counties. Quartz is the principal constituent of the graphite-bearing schist, with subordinate amounts of pyrite, mica (biotite), and apatite. These bands of schist rarely exceed 100 feet in thickness and appear to be fairly continuous, though prospecting has not yet proceeded sufficiently to establish their continuity over long distances. The average graphite content of the ore in terms of graphitic carbon is 3 or 4 per cent, though in some places analyses show a carbon content of 5 or 6 per cent. In nearly every deposit the graphite schist is intruded by small stringers of pegmatitic granite. These contain only a little graphite, but appear to have caused a more intense recrystallization of the original carbon in the intruded rock, which has resulted in a coarsening of the flake in the immediate vicinity and possibly in an actual enrichment in the graphite content. The wall rocks are in most places schists that are similar in type to the graphite-bearing schist but contain less graphite and more mica. At a few localities, however, one wall consists of hornblende schist, probably an altered basic intrusive. No graphite is found where the hornblende schist is intruded by granite—an evidence that the carbon from which the graphite is derived is not a product of the granite intrusion. The graphite schists commonly crop out along ridges, and, as a rule, the overburden is very light. The pyrite of the deposits is in most places completely oxidized to the depth of 50 to 60 feet. Besides removing this very objectionable constituent of the ore, weathering has softened the rock and lessened the coherence between the graphite and the other minerals, which facilitates both mining and concentration. The unoxidized schist is avoided as far as possible in mining operations, as it is hard to crush, and the pyrite can be completely eliminated from it only with difficulty. It would, however, be perfectly feasible to treat this "blue rock" should necessity arise.

The following recent articles are of interest in regard to the graphite deposits of Alabama:

Prouty, W. F., Flake graphite in Alabama; its location, its history, and its value to the State: Birmingham Age-Herald, January 28, 1917.

——— Extent and development of flake graphite resources of Alabama: Manufacturers' Rec., April 19, 1917, pp. 66-67.

Pratt, J. H., Alabama graphite deposits: Manufacturers' Rec., March 22, 1917, p. 58.

Herr, Irving, Clay County graphite district of Alabama: Eng. and Min. Jour., vol. 103, pp. 693-697, April 21, 1917.

MINING AND CONCENTRATION.

Mining is done in open cuts, and in common practice a 30-foot face is broken down with a single charge of dynamite and the material loaded into cars. The large blocks are broken by hand or by small charges of powder. In loading a certain proportion of low-grade material is discarded. The deposits with steep dips are, of course, at an advantage over others in the costs of mining.

Milling methods are much the same in most of the mills and may be described briefly. Large bins have been installed in most of the newer mills to allow steady runs even in wet weather, as it is of great advantage to have the ore as dry as possible. The ore passes to a jaw crusher, where it is broken to about 1-inch size and next to a rotary cylindrival drier. In some mills rolls are used before drying. The dry ore is next crushed in rolls and screened, the oversize going back to the rolls and the fines passing to the water flotation concentrator. In some mills the crushed ore first passes through an air separator in which a suction fan removes the graphite and dust and leaves the coarser sand behind. This process is open to the objection that a certain quantity of coarse flake is left behind with the sands and some fine graphitic dust is inevitably lost. Where a middling product is made it is returned to the rolls. In some of the newer mills the graphitic sands pass from the drier into cooling bins, where they remain 24 hours, the bins being drawn on alternate days. The reason for this is that water flotation has been found to act more effectively on cool material.

The principal concentration process is water flotation. The flotation separator is a rectangular trough 5 to 9 feet long, 6 to 10 inches wide, and 12 to 18 inches deep. This trough is filled with water, which is supplied in a thin curtain from the top along the entire length of one side and overflows into a launder on the other side. The amount of water is regulated so that the flow across the trough shall be as smooth and free from ripples as possible. The graphitic sand is fed in a thin stream onto the moving water surface. In a few mills the sand is fed over a revolving shaft which distributes the feed more evenly. Most of the sand sinks, and the graphite flakes, together with a little mica and fine grit, float off on the moving water. A recent modification of the flotation separator is circular in form and about 6 feet in diameter, and in it the sand is fed at the apex of a stationary or revolving cone.

The launders carry the concentrates to shaking screens, on which they are freed from surplus water. Fine sprays falling on these screens wash out a part of the fine grit. In one mill a hexagonal reel is used instead of the shaking screen. The concentrates are next dried on a concrete drying floor heated by steam or in double-chambered rotary cylindrical driers. In some mills the concentrates then pass through another air separator. This removes whatever coarse grit has been floated with the graphite.

The finishing process consists of grinding in burrstone mills and screening in bolting reels or inclined shaking screens of the kind used in flour mills. The purpose of the burr mill is to break the grains of quartz so that they will pass through the finest screen with the dust while the No. 1 and No. 2 flake remains as oversize from the different screens. In a few mills electrostatic separation has been tried in place of burr mills for the final finishing, but in the Clay County mills it has not proved satisfactory.

Three mills use processes different from that outlined above. The new mill of the Alabama Graphite Co. uses a wet process for the preliminary concentration. The material is crushed in jaw crushers and is then fed with water into the muller and from that to a log washer, in which the sands are screened toward the discharge at the upper end while the graphite flakes float off at the lower end. The dewatering and finishing process is the same as that outlined above. The Ceylon Co. uses an oil-flotation process and the Flaketown Graphite Co. uses a dry process throughout.

The usual Alabama system as outlined above is open to the following objections:

1. The recovery is low; in most mills the total of the finished product amounts to about 2 per cent of the ore handled. As none of the final product is pure graphite, this probably means a total saving of not over 60 per cent of original graphite content.
2. The quantity of dust is too great in proportion to the quantity of No. 1 flake produced. The proportion of different products varies from 40 to 50 per cent of No. 1 flake, 25 to 15 per cent of No. 2 flake, and 40 to 35 per cent of dust. Grinding dry in the muller or Chile mill and the final grinding in the burr mills probably breaks the flake badly.
3. Under the present system the ore must be dried before the graphite can be separated by water flotation and the concentrates must be dried again before finishing. A wet concentration process would eliminate the preliminary drying.
4. There is no uniform standard for No. 1 flake. A few producers guarantee a 90 per cent carbon content but the majority produce No. 1 flake carrying about 85 per cent.
5. The dust-filled mills can not fail to be injurious to the health of the workers.

The organization of the Graphite Association of Alabama (A. B. Conklin, secretary, Ashland, Ala.) has been of great assistance to the industry, as it enables the graphite producers of the State to take united action in matters affecting the mining industry, such as the railroad embargo. The association is preparing to obtain a better standardization of the Alabama flake.

The following Alabama companies either reported sales during 1917 or expected to begin operations during the early part of 1918:

Graphite producers in Alabama.

Company:	Location of plant:
Chilton County:	
Flaketown Graphite Co., Mountain Creek	Mountain Creek
Clay County:	
Acme Graphite Co., Ashland	Ashland
Alabama Graphite Co., Ashland	Ashland
C. B. Allen Graphite Co., Ashland	Ashland
American Graphite Co., Gadsden	Ashland
Ashland Graphite Co., Ashland	Ashland
Atlas Graphite Co., Ashland	Ashland
Axton Noe Graphite Co., Ashland	Ashland
Clay County Graphite Co. (Inc.), Ashland	Ashland
Crystalline Flake Graphite Co., Birmingham	Ashland
Empire Graphite Co., Ashland	Ashland
Griesemer Graphite Co., Ashland	Ashland
Hood Graves Graphite Co., Alexander City	Ashland
Jefferson Graphite Co., Birmingham	Ashland
May Bros. Graphite Co., Ashland	Ashland
National Flake Graphite Co., Ashland	Ashland
Republic Graphite Co., Ashland	Ashland
Southern Graphite Co., Ashland	Ashland
Superior Flake Graphite Co., Ashland	Ashland
Crucible Flake Graphite Co., 50 Broad street, New York, N. Y.	Ashland
Carbon Mountain Graphite Co., Lineville	Graphite
Liberty Graphite Co., Birmingham	Lineville
Jennings Graphite Co., Lineville	Lineville
Morris Graphite Co., Lineville	Lineville
King Graphite Co., Lineville	Lineville
Lineville Graphite Co., Lineville	Lineville
Peerless Flake Graphite Co., Lineville	Lineville
Eagle Graphite Co., Ashland	Quenelda
Norway Graphite Milling Co., Clairmont Springs	Quenelda
Quenelda Graphite Co., Quenelda	Quenelda
Coosa County:	
Ceylon Co., Birmingham	Hollins
Duro Graphite Co., Sylacauga	Sylacauga
Graphite Co. of America, Goodwater	Good Water
Good Water Graphite Co., Good Water	Good Water
Parkdale Graphite Products Co., Talladega	Parkdale

FUTURE OF THE GRAPHITE INDUSTRY.

DOMESTIC.

Even at the present war prices the miners of this country who are working deposits of disseminated flake graphite must depend on their No. 1 and No. 2 flake for their profit. The dust and lower-grade flake produced are merely by-products and are salable only at a very low price. The object of the operators is consequently to produce as large a proportion of flake as possible. The usual process of finishing involves grinding in burr mills in order to break the small particles of quartz and allow them to be separated out by screening. This process necessarily breaks the flake and increases the amount of dust. Developments in graphite milling practice during 1917 give promise of a largely increased production of flake of better grade. Among the new methods is oil flotation, particularly in the Alabama field, where several companies are using it with marked success. If flake graphite holds its present prices, profits can be made by a mill of almost any type, but at the prices that prevailed in time of peace only the most efficiently managed mills can hope to survive. Madagascar's output is increasing rapidly, and after the war domestic producers will have to meet competition from this island as well as from Ceylon. If Madagascar graphite can in normal times be put on the London market at a cost of approximately 4 cents a pound,* the price at New York would not be much higher, and it can readily be seen how formidable a competition will have to be met by the domestic producers when the shipping situation becomes normal again and how essential it is that the methods of mining and milling should be brought to as high a degree of efficiency as possible. The Ceylon graphite is considered by American manufacturers to be better suited to the manufacture of crucibles and will probably continue to command a higher price than the domestic. The costs of mining in Ceylon have advanced considerably in recent years, however, since deep mining has become necessary, and it is probable that unlike Madagascar, which is a new field, Ceylon will not increase her production greatly. Moreover, it is probable that the greater use of the electric furnace in metallurgic operations will somewhat retard the demand for graphite crucibles. The following table shows the notable development in electric-furnace steel during the last few years, while the production of crucible steel has remained about stationary.

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*Shelley, J. W., Graphite in Madagascar: Min. Mag., vol. 14, p. 327, 1916.

Steel ingots and castings, produced in the United States, 1908–1916, by processes, in gross tons.*

	Crucible	Electric		Crucible	Electric
1908	63,631	—	1913	121,226	30,180
1909	107,355	13,762	1914	89,869	24,009
1910	122,303	52,141	1915	113,782	69,412
1911	97,653	29,105	1916	129,692	168,918
1912	121,517	18,309			

*Am. Iron and Steel Inst. Ann. Rept. for 1916, p. 24, New York, 1917.

Under conditions such as prevailed in the summer of 1917 nearly any grade of flake graphite is salable, and there are no definite standards governing specifications. Consequently, other things being equal, the buyer will prefer the imported graphite, for which there are fairly well recognized standards. It would seem advisable for the domestic producers, now that their product is in good demand, either to adopt standards for different grades of flakes, in order that when imported graphite comes on the market more freely they may be better able to meet the competition, or so to regulate their milling methods that they may be able to prepare special grades based on the purchaser's specifications. It is probably impossible to standardize grades for the whole country, owing to the different methods of treatment necessary for different types of ore, but where conditions are essentially the same over a large area, as in the Alabama field, co-operation among the producers might result in the establishment of two or three standard grades, based on the percentage of graphitic carbon and size of flake, with a guaranteed minimum of silica and iron. This would give the producers a far stronger position in the market and make the crucible manufacturers more ready to use domestic flake.

Graphite for other uses, such as for lubricants, pencils, foundry facings, and paints, will probably continue to be in good demand, but unless the deposits are large and cheaply mined, the prices of the grades required for these uses do not make them profitable to the producer. Here again the expected competition after the war of the graphite dust from Madagascar and Ceylon and amorphous graphite from Mexico and Chosen, as well as artificial amorphous graphite, will be difficult to meet. Better milling methods, resulting in a higher graphite content of the dust produced, will aid the situation greatly. For instance, dust as ordinarily produced at flake graphite mines carried about 40 per cent carbon and is sold at less than 1 cent a pound, but this same dust when refined to a degree of purity suitable for use as a filler for dry batteries commands many times this figure.

Perhaps it may be found feasible to manufacture many graphite products in the vicinity of the mines. In this connection an article by Bartley is worthy of attention.

The large number of new companies beginning operations at the present time naturally makes it of importance to consider the probable effect of the future increased production upon the market. If all the mills in the Alabama field are able to operate at anything like their expected capacity, the result will be an annual production of flake graphite of approximately 30,000,000 pounds, about 15 times the production of Alabama in 1913, and nearly equal to the entire importation from Ceylon for that year. As long as the war continues a largely increased production can probably be absorbed by crucible makers and other users of crystalline graphite, but if the graphite from Ceylon and Madagascar continues to enter the market freely, the price of domestic graphite will necessarily be reduced with the increase in production. On the other hand, mining conditions in Alabama are very favorable, the mining costs are low, and new developments in concentration and finishing will probably result in a larger percentage of good flake in the finished product and a higher saving of graphite of all grades. Costs of mining and milling at an efficiently managed plant should not exceed $50 a ton of concentrates produced, or about 2½ cents a pound for the finished product, and even with prices as low as 5 cents a pound for No. 1 flake, 3 cents for No. 2, and 1½ cents for dust, there should still be a possibility of profit. A recent article by Prouty* contains an interesting discussion of costs of production of graphite in Alabama. It is of course idle to speculate on the possible duration of present conditions, and the situation may be summed up by saying that as long as the present demand for crucibles in the manufacture of munitions continues, the plants in operation should all be able to make profits, and even with the expected drop in prices after the war the most favorably situated and efficiently managed plants should continue to be profitable.

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*Prouty, W. F., Extent and development of flake graphite resources of Alabama; Manufacturers' Rec., Apr. 19, 1917, pp. 66-67.

With a return of peace, however, operators will face an unfavorable condition caused by a decreased market and large increase in production.

IRON ORE.

ERNEST F. BURCHARD.

EUGENE A. SMITH.

ESSENTIAL FEATURES OF AN IRON-ORE DEPOSIT.

THE war in Europe has greatly stimulated prospecting for minerals and ores in the United States, and as a result of this prospecting many specimens are sent to the United States Geological Survey for identification. The majority of specimens are readily identified at sight; some require a brief visual examination; others require more elaborate physical or chemical tests. The Survey is not permitted to make chemical analyses or assays of minerals or ores for private persons or corporations, but it is compatible with the duties of the Survey to inspect a specimen and to state, if possible, what it is; to give an offhand opinion as to whether or not the material constitutes an ore; and to recommend or discourage further expense in prospecting it or in having analyses or assays made.

Iron minerals are among the most common and are abundantly distributed, and naturally many specimens are received by the Geological Survey. It is therefore believed that a few notes on these minerals and on the requirements of a deposit in order to render it of commercial importance may be of interest to those making inquiries on the subject. The classes of iron minerals that constitute a source of iron ore are oxides and carbonates. There are three general varieties of oxides, viz., hematite, brown ore, and magnetite. Brief descriptions of each follow:

SOURCE OF IRON.

The forms in which iron occurs in the earth in combination with other substances are very numerous. Nearly all hard rocks, as well as the softer soils, sands, clays, and many "mineral" waters contain iron in some combination and in varied proportions. Iron is seldom found "native"—that is, occurring in the earth in the form of metallic iron. When it is found in the metallic state, as, for instance, in meteorites that have fallen from space upon the earth, it is not in quantities large enough to be of commercial value. The combination of iron with one or more other substances is called an iron compound, or iron mineral, and where the iorn compounds are such that iron can easily be extracted from them and they occur in such abundance that they can be mined profitably these iron compounds are called iron ores.

Iron in combination with other substances is regarded next to aluminum, a metal contained in clay, as the most abundant metal. Thus, according to recent calculations,* metallic iron forms about 4.50 per cent of the rock crust of the earth, compared with 7.85 per cent for aluminum.

IRON ORE.

There are four important types of ores of iron—red iron ore, or hematite; brown ore, or limonite; magnetic ore, or magnetite; and carbonate ore, or siderite—although there are hundreds of minerals in which iron is a constituent. These types of ore may easily be remembered through their most common colors, which are, respectively, red, brown, black and grayish.

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*Clarke, F. W., The data of geochemistry, 3d ed.; U. S. Geol. Survey Bull. 616, p. 34, 1916.

Hematite.

Hematite includes all varieties of the anhydrous sesquioxide (Fe_2O_3). This is known locally as red hematite, specular ore, gray ore, fossil ore, oolitic ore, etc. Hematite is composed of two parts of the metal iron united with three parts of oxygen. Iron forms 70 per cent by weight of pure hematite and oxygen 30 per cent, and the mineral is known chemically as the sexquioxide of iron or ferric oxide. Hematite may occur as a rock in beds, in veins, or in masses of irregular shape, and it may occur in a soft, earthy state, or as a loose debris in the soil, and yet in all these forms be profitably mined if the controlling conditions are favorable. Hematite is easily recognized in the hand specimen by its colors (red to steel-gray and black) and the red mark or streak it leaves when drawn across a rough surface and by its high specific gravity or superior weight as compared with the weight of pieces of ordinary red rock or red clay of equal size. The old-fashioned "keel" or red chalkstone formerly used by carpenters for marking lumber is a form of hematite. Finely ground hematite is used in the manufacture of red paint and other red coloring materials.

Hematite is by far the most important iron ore. It is found in great abundance in the United States in the vicinity of Lake Superior in Minnesota, Michigan, and Wisconsin; in central New York; in the Appalachian region of Alabama, Georgia, Tennessee, and Virginia; and in eastern Wyoming. It also occurs in lesser quantities in Pennsylvania, Maryland, Kentucky, eastern Wisconsin, Utah, and California. (E. F. B.)

All the ore of this quality mined in Alabama occurs in the Clinton or Red Mountain formation. The Red Mountain ridges occur on each side of the anticlinal valleys which separate the coal fields. In places the red ore ridges are lacking on one side, usually the western, of the valleys, being cut out by faults, while on the other hand the ridge may be duplicated on one side of the valley by the same faults.

In most of the valley occurrences the moderate dips of the ore bed are on the eastern side and there are also practically all of the ore mines. Murphree's Valley makes an exception to this, the moderate dips and the iron mines being on the western side. The iron ore occurs mainly in the central part of the formation in seams or beds one to five in number, which vary in thickness from a few inches to thirty feet.

While the ore seams are very persistent along the outcrop which in Alabama must be as much as 50 miles, yet they vary greatly from place to place, being either too thin or too lean for profitable working in the greater part of this distance.

The most important development of the Clinton ore in this State and in the world is along the 15 or 16 miles stretch of the east Red Mountain between Birmingham and Bessemer, and there is a practically continuous series of mines and strippings for this entire distance. Much mining of this ore has also been done near Gate City, Village Springs, Attalla, Gadsden, Round Mountain, Gaylesville, Fort Payne, Valley Head, etc.

The completion in October, 1912, of a diamond drill boring in Shades Valley, within a mile of the base of Shades Mountain, gives a definite answer to the speculations concerning the occurrence of red ore under Shades Valley. This boring shows that there is no falling off in the thickness and quality of the ore with distance from the outcrop, and that the depth of the ore below the surface at a distance of more than 2½ miles from the outcrop on Red Mountain is not too great for shaft mining.

The importance of this demonstration of a vast increase in the amount of red ore available immediately or in the near future, cannot well be overestimated.

In 1913 the Gulf States Steel Company acquired about 1,500 acres of land upon which the drill hole above mentioned was located. They have since sunk a double track slope to the ore. In time this is likely to be the largest producing mine in the State.

Another drill hole was put down in Shades Valley in 1913, in Section 19, T. 19, R. 3 W., but the record was not available for publication at the present time.

The hematite production in Alabama in 1917 was 5,949,096 tons, as against 4,672,005 tons in 1916, an increase of 277,091 tons or 4.89 per cent. The 1917 production of hematite is 84.6 per cent of the total iron ore production of the State, and 8.44 per cent of the total iron ore production of the United States.

The average price of hematite in Alabama in 1916 was $1.52; in 1917, $1.61.

Brown Ore.

Brown ore is composed of iron, oxygen, and water, and in a general way might be said to be hematite combined with water. A general formula may be expressed by $mFe_2O_3nH_2O$. Brown ore may contain water in several proportions so that the percentage of iron likewise varies, but the latter ranges generally from 52 to 66 per cent in the pure mineral. Thus brown ore does not contain quite as high a percentage of iron as hematite, and therefore it can not yield so much metal. One of the most common brown ore minerals is known as limonite ($2Fe_2O_33H_2O$), and this contains 59.9 per cent of iron, 25.7 per cent of oxygen, and 14.4 per cent of water. Brown ore occurs in a large variety of forms, nearly all of which have in common a characteristically yellowish-brown to chocolate-brown color and yield a brown streak and powder. Exceptionally certain hydrated sesquioxides of iron may appear bright red, and some may show black surfaces; but these exceptional forms are generally to be found closely associated with a mass of ordinary brown ore, and familiarity with the deposits soon dispels any perplexity regarding the nature of the ore on the part of persons mining or handling it. The specific gravity of brown ore is also higher than that of ordinary rock. Brown ore commonly occurs in irregular masses and lumps, and as ore gravel and sand, embedded in banks of clay, sand, and stone gravel. The ore in places lies in layers, but more commonly in irregular pockets, separated by barren clay, sand, and stone gravel. In places the ore takes the form of hollow concretions or "pots" which may contain some loose sand or clay in the interior and also it appears as honeycombed masses ramifying through the inclosing ore-bearing ground.

Limonite is used chiefly as a source of iron, but the brown and yellow forms, called ocher, are used for paint and for making oil-cloth and linoleum. A porous variety of limonite is used in the purification of illuminating gas, and also as a contact material in the production of hydrogen gas for inflation of dirigible balloons and for precipitation of fats from oils. Many iron compounds are used in medicines.

Deposits of brown iron ore are common in many portions of the eastern United States, particularly in valleys underlain by limestone. Some of the best-known deposits are in Connecticut, Vermont, Pennsylvania, Virginia, Tennessee, Alabama, northeastern Texas, and in Iowa and Wisconsin near Mississippi River. (E. F. B.)

This ore, the second in importance in the State, and third in the United States, furnishes only 1.58 per cent of the total iron ore production of the United States, and 15.5 per cent of the iron ore production of the State in 1917. The entire brown ore production of the United States in 1917 was 1,973,096 long tons of which Alabama contributed 1,088,611 tons or 55.2 per cent, and the State holds accordingly the first rank in this industry.

In the early days of iron making and up to the year 1876 this was the only ore used in the catalan forges, bloomaries, and charcoal furnaces of the State. It was then demonstrated that good iron could be made at low cost from the red ores, with coke for the fuel.

In general the limonites are considered the best of the ores of Alabama, commanding the highest prices and a ready sale.

The usual mode of occurrence is in irregular masses of concretionary origin in the residual clays resulting from the decomposition of limestones, and as a consequence the mining is uncertain and expensive. Limonite also occurs in regularly stratified seams or beds, and then it is the result of the alteration of pyrites or of carbonate ores. Practically all of the brown ore actually mined is that occurring in the residual clays above mentioned. Most of the ore before going to the furnace is washed and screened, and this manipulation, together with the cost of mining, makes it the most expensive of the iron ores, and it is therefore seldom used alone, but is usually mixed with the red ore in proportions determined by the quality of the iron desired. It is used alone in the charcoal furnaces and also in the coke furnaces when a particularly tough pig iron is wanted.

The limonite deposits are very numerous and are distributed over a broad expanse of country and in many places are known to be very extensive. In some of the deposits the ore is in nearly solid mass, in others it is much scattered, and in consequence the amount of foreign material necessary to be removed for every ton of ore produced, varies very much, not only in the different ore banks, but also in the different parts of the same bank.

The deposits occur in nearly all the geological formations of the State, but in most of these the ore is either insufficient in quantity or not pure enough to be of much commercial value. The most important of the deposits, in point of extent and value, occur overlying the following formations, viz., the Knox Dolomite and the Weisner Quartzite, the Lauderdale Chert of the Lower Carboniferous, and the Lafayette. Some extensive beds of ore of inferior quality generally occur also in the Tuscaloosa formation of the Cretaceous, and in the upper part of the Lower Carboniferous and in the Metamorphic rocks.

The limonite or brown ore production of Alabama in 1917 was 1,088,611 long tons as against 1,075,896 tons in 1916, an increase of 12,715 tons or 1.8 per cent.

The average price per long ton of brown ore marketed in Alabama in 1917 was $3.08, as against $1.97 in 1916. (E. A. S.)

Magnetite.

Magnetite (Fe_3O_4) is a black ore of iron which is attracted by the magnet. It contains iron and oxygen in the proportion of 3 parts of iron to 4 parts of oxygen, which by weight gives 72.4 per cent of iron and 27.6 per cent of oxygen. Magnetite thus contains the highest percentage of iron of the ores thus far mentioned, and in fact, of all the iron ores. Magnetite usually occurs in granular form and in crystals in veins in comparatively old crystalline rocks, although it may be found in comparatively young volcanic rock.

Magnetite is found in the United States in considerable quantities in the Adirondack region of New York, the Highlands of New Jersey, south Pennsylvania, eastern Wyoming, central Texas, southwestern Utah, and southern and northern California, and in small quantities in northern Michigan and in other states. It is used chiefly for the production of iron, but the less common variety known as lodestone, which is naturally magnetic, is sold at high prices for museum exhibits and for laboratory purposes. Magnetite is found in the form of sand along streams and on the shores of lakes or seas where it has been concentrated by the action of water. In this form it has not proved of much commercial value as an ore of iron. (E. P. B.)

There has been no development of magnetic ore properly speaking, in Alabama. The gray ore of Talladega County which was mined to some extent a few years ago is essentially a hematite though some of it is slightly magnetic. There was no production of this ore in 1917. (E. A. S.)

Siderite.

Siderite, or iron carbonate ($FeCO_3$), is composed of 1 part of iron, 1 part of carbon, and 3 parts of oxygen and thus contains by weight where pure, approximately 48.3 per cent of iron, 10.3 per cent of carbon, and 41.4 per cent of oxygen. Iron carbonate ore where fresh is generally grayish in color, and occurs in nodules and in layers principally in sedimentary rocks that contain coal and lignite. The carbonate rapidly changes to brown ore on exposure to moist air. Siderite is known locally as spathic iron ore, kidney ore, clay ironstone, and blackband ore. Certain of these names are derived from the appearance of the ore in its different forms. For instance, a bed of carbonate ore that is found on the top of a coal bed in eastern Kentucky is striped with fine black carbonaceous bands.

Iron carbonate, in addition to being found in Kentucky, is common in southeastern Ohio, and occurs to a small extent in Pennsylvania, Alabama, Mississippi, and Texas.

IMPURITIES IN IRON ORE.

Consideration should be given to some of the principal impurities that are found in iron ores, first, in order to appreciate why a deposit of ore never yields the full percentage of iron that the predominant iron mineral contains, and, second, in order to show the relation of the ore to the operation of the blast furnace. Deposits of iron ore are generally so closely associated with the rocks which inclose them that they contain either mixed with the deposit or chemically combined within it some of the other rock-forming minerals. Among the most common of these minerals are silica, or sand; lime and magnesia, derived from limestone and dolomite; alumina, a clay mineral; manganese, a metal resembling iron; and small quantities of sulphur and phosphorus. The presence of varying percentages of these and other minerals tends, of course, to reduce the percentage of metallic iron that the deposit will yield when mined, and they must be removed as far as possible in mining and almost completely in the process of making iron. Therefore, it is of the utmost importance that the average chemical composition of a deposit of iron ore be ascertained before an attempt is made to mine it.

The average composition may be termed the "quality" of the deposit. The quality is determined chiefly by two men, the prospector and the chemist. The prospector digs trenches and pits or drills holes in the ore and takes samples of it. The chemist analyzes these samples of ore in his laboratory, and finds the percentages of metallic iron, silica, lime, alumina, manganese, sulphur, phosphorus, water, etc., contained in average samples of the ore. On the quality of the ore depend the quantity of fluxing stone and fuel that must be used in the blast furnace and the kind of iron that can be produced.

RANGE IN COMPOSITION.

Many chemical analyses of commercial grades of these iron ores indicate a range in composition given in the following table:

Range in chemical composition of commercial grades of iron ore.

	Hematite Per cent	Brown ore Per cent	Magnetite Per cent	Carbonate Per cent
Metallic iron	25-65	35-58	48-70	25-48
Silica	2-35	3-23	0.6-20	1-23
Alumina	0.2-9	1.4-12	0.7-4.5	1-5
Lime	Trace to 27	0-0.6	0.5-4.5	0-7
Manganese	Trace to 5	0.16-5	0.07-1.5	0.1-4.7
Sulphur	Trace to 1.5	Trace to 0.5	Trace to 1.2	0.01-1.8
Phosphorus	0.013-1.23	0.04-1	Trace to 1.75	0.043-0.7
Titanium	0-0.9		0-1.5	0-0.04
Water	0.3-6	8.8-15	0.25-0.5	0-6.5

Under exceptional conditions ores are mined that contain more or less of the common constituents indicated above, but local conditions may determine whether an ore that falls within the limits shown may be mined. For instance, hematite carrying as little as 20 per cent metallic iron would not be considered of value as an ore unless it contained enough lime to flux the silica and alumina present. Most Southern red hematites contain considerable quantities of lime and are therefore workable where a highly siliceous ore carrying no more metallic iron and little lime would not be available under present conditions of metallurgic practice. At present ores averaging less than 25 per cent of metallic iron are not charged into blast furnaces in any considerable quantities, and ores as lean as this can not be used economically unless they carry more than enough lime to flux them and are used in connection with richer ore. In using limestone as a flux it would probably be more desirable to use a stone carrying 15 to 20 per cent of ferric oxide (10.5 to 14 per cent metallic iron) than one containing only 3 to 5 per cent ferric oxide, on account of the higher iron yield of the former. Nevertheless, the more ferruginous limestone would not commercially be classed as an ore; yet a bed carrying 35.5 per cent ferric oxide (25 per cent metallic iron), although in itself not quite rich enough might be conceded to be an "ore." There are other exceptions to be noted in this table. Some deposits of nontitaniferous magnetite can be so treated by means of crushing and electromagnetic separation that, although they may contain as little as 25 per cent metallic iron, they will yield a high grade concentrate. Such ores may be used to advantage, especially where they can be concentrated along with richer grades. Considerable phosphorus is present in the mineral apatite associated with Adirondack magnetite; and this and silica are largely eliminated by electromagnetic concentration. The possibilities of various methods of concentration or beneficiation must therefore be taken into consideration in appraising an ore, and this involves consideration of the physical as well as the chemical character of the ore. The content of water is a widely variable item. Some ores contain much absorbed water, which can be driven off by drying. Hematite is found in all stages of hydration, and thus may contain water up to the point where it should really be classed as a brown ore. Hydrated ores are thus concentrated by heating to drive off the chemically combined water. Carbonate ores are calcined to drive off both carbon dioxide and water. Some iron oxides are subjected to a partial reduction and are thus rendered magnetic, and the separation of nonmetallic impurities is thereby greatly facilitated. One brown-ore deposit that averages in the raw state not more than 30 per cent of metallic iron is thus through a complicated process of beneficiation rendered of commercial value. The question of beneficiation is therefore becoming increasingly important; and there must also be taken into consideration the proximity to transportation, and to blast furnaces, to water-power sites for possible electric reduction, as well as the prevailing conditions of the market. The laws of supply and demand that prevail in 1917 make available lower grades of ore than would be considered desirable in times when low prices for iron and steel are current. The question of quantity available is also of importance, for iron ore is so bulky a product, is relatively so low in value even at the best, and involves so large an expenditure for equipment for mining on a satisfactory scale that any deposit should contain several years' supply to be worthy of development.

To summarize, then, the ore should occur in a deposit containing several hundred thousand tons of merchantable grades, susceptible of economical mining and convenient to transportation and markets, if its development is to be seriously considered. (E. F. B.)

DETAILS OF IRON ORE PRODUCTION IN ALABAMA, 1916-1917.

The following tables show details concerning the production of iron ore in the State, together with the rank of the State in mined and marketed iron ore in 1916 and 1917:

Ore mined in Alabama, 1916–1917, by varieties, with percentage of increase in 1917 in long tons.

YEAR	Hematite	Brown ore	Total Quantity	Percentage of total U. S. Produc'n.
1916	5,672,005	1,075,896	6,747,901	8.99
1917	5,949,096	1,088,611	7,037,707	9.37
Increase	277,091	12,715	289,806	
Percentage	4.89	1.8	4.29	

Iron ore shipped from Alabama mines, 1916–1917.

YEAR	Quantity (Gross tons)	Value
1916	6,801,839	$10,843,231
1917	7,101,586	13,049,535
Increase	299,747	2,206,304
Percentage	4.4	20.3

Average price per gross ton of iron ore shipped from mines in Alabama and the United States, 1916–1917.

	HEMATITE		BROWN ORE	
	1916	1917	1916	1917
Alabama	$1.52	$1.61	$1.97	$3.08
United States	2.32	3.12	2.03	2.95

General average, 1916, $2.34; 1917, $3.15.

Rank of the first five states in mined and marketed production of iron ore in 1916 and 1917.

1916

Rank	STATE	MINED		MARKETED			
		Quantity (long tons)	Percentage of total product'n	Quantity (long tons)	Percentage of total product'n	Value	Percentage of total value
1	Minnesota	44,585,422	59.31	45,869,251	58.91	$106,628,784	58.62
2	Michigan	18,071,016	24.04	18,995,797	24.27	49,054,340	26.97
3	Alabama	6,747,901	8.99	6,801,839	8.61	10,843,231	5.96
4	New York	1,342,507	1.78	1,464,917	1.88	5,571,429	3.06
5	Wisconsin	1,304,518	1.72	1,529,459	1.96	3,644,542	2.00

1917

Rank	STATE	Quantity (long tons)	Percentage of total product'n	Quantity (long tons)	Percentage of total product'n	Value	Percentage of total value
1	Minnesota	44,595,232	58.4	44,962,127	59.5	$142,901,148	60.0
2	Michigan	17,868,601	23.4	17,712,916	23.4	62,833,624	25.4
3	Alabama	7,037,707	9.4	7,101,586	9.4	13,049,535	5.48
4	New York	1,304,317	1.7	1,356,011	1.79	7,381,833	3.07
5	Wisconsin	1,202,235	1.57	1,179,709	1.56	3,913,487	1.64

PRINCIPAL IRON ORE MINES.

In 1916 there were 452 iron ore mines active in the United States, and 212 mines in 1917 produced more than 50,000 gross tons of iron ore each, compared with 222 mines in 1916. Of these 212 mines, 11 produced more than 1,000,000 tons of iron ore each in 1917, 1 less than in 1916. First place in 1917 was held by the Hull-Rust mine at Hibbing, Minn.; second place by Red Mountain group near Bessemer, Ala. The production of the Alabama mines producing more than 50,000 gross tons each in 1917 is given below in tabular form.

Iron ore mines of Alabama that produced more than 50,000 long tons each in 1917.

	Name of Mine	Nearest Town	Variety of Ore	Quantity
1	Red Mountain Group	Bessemer	Hematite	2,955,022
2	Woodward, Nos. 1, 2 and 3	Lipscomb	Hematite	877,637
3	Songo	Songo	Hematite	283,362
4	Spaulding	Birmingham	Hematite	213,968
5	Raimund, No. 1	Bessemer	Hematite	201,665
6	Steinman	Steinman	Hematite	159,342
7	Attalla	Attalla	Hematite	128,029
8	Greely	Greely	Brown Ore	119,070
9	Hammond	Hammond	Hematite	114,713
10	Ironaton	Ironaton	Brown Ore	84,771
11	Vaney	Russellville	Brown Ore	78,693
12	Raimund, No. 2	Bessemer	Hematite	68,520
13	Tannehill	Goethite	Brown Ore	63,786
14	Friedman	Woodstock	Brown Ore	61,795
15	Houston	Rickey	Hematite	57,151
16	Wilson: Hyde and Hurst	Russellville	Brown Ore	54,029
17	Champion	Oneonta	Brown Ore	51,906

BENEFICIATED IRON ORE.

Statistics of beneficiated iron ore have been gathered by the Survey for the years beginning with 1914 and, although complete returns were not at first received from every producer who subjects his ore to any form of beneficiation, the responses to the special inquiries have been, on the whole, satisfactory and interesting and have shown continued improvement.

The following processes were reported as employed to improve the quality of the ore at various mines: Crushing and screening, drying by direct heat and by steam, hand picking on tables and on belts, washing by means of hydraulic jets and logs, jigging, electromagnetic cobbing, other concentration and separation, calcining, nodulizing, and desulphurization by sintering. Some of the operations combined two or more of these processes. Iron ores were reported as beneficiated at 94 mines in 16 states in 1917 and at 83 mines in 14 states in 1916.

In Alabama the ore treated was principally brown ore, and the usual processes to which it was subjected were log washing, screening, and picking belt. A total of 1,159,624 gross tons of beneficiated ore, valued at $3,324,715, was marketed from 19 mines in Alabama in 1917, compared with 996,344 tons, valued at $1,969,706, from 12 mines in 1916. Of this quantity 242,742 tons were hematite run over a picking belt.

PIG IRON.

PRODUCTION, SHIPMENTS, AND VALUE, BY STATES.

THE bureau of statistics of the American Iron and Steel Institute reports the production in 1917 of all kinds of pig iron, including such ferroalloys as spiegeleisen, ferromanganese, ferrosilicon, and ferrophosphorus, produced in blast furnaces as well as some that were electrically produced, as amounting to 38,621,216 gross tons, compared with 39,434,797 tons produced in 1916, a decrease of 813,581 tons, or about 2 per cent.

*Pig iron, including some ferroalloys, manufactured in the United States in 1916 and 1917, in gross tons.**

	1916	1917		1916	1917
Pennsylvania	16,506,284	15,539,728	Virginia	399,885	520,311
Ohio	8,602,895	8,518,603	Missouri	437,683	453,742
Illinois	3,922,512	3,456,915	Iowa†		
Alabama	2,762,885	2,953,705	Colorado		
Indiana	2,221,708	2,657,503	Washington		
Michigan			California		
New York	2,352,585	2,417,527	Maryland	501,452	422,212
New Jersey			Tennessee	355,374	369,951
Wisconsin	811,325	738,541	Connecticut	5,719	10,527
Minnesota			Massachusetts		
West Virginia	554,590	561,951			
Georgia				39,434,797	38,621,216
Kentucky					

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*Bureau of statistics of the American Iron and Steel Institute.

†Ferrosilicon produced in electric furnace for first time in 1916.

Pig iron shipped from blast furnaces in the United States in 1916 and 1917.

STATE	1916		1917		Change in 1917		Percentage change, 191	
	Quantity (gross tons)	Value	Quantity (gross tons)	Value	Quantity (gross tons)	Value	Quantity	Value
Alabama	$2,672,498	38,994,660	2,971,626	$64,309,714	+ 299,128	+$25,315,054	+ 11	+ 65
Illinois	3,857,391	67,764,309	3,458,126	91,094,541	— 399,265	+ 23,330,232	— 10	+ 35
Kentucky	144,444	2,595,600	192,204	5,582,367	+ 47,760	+ 2,986,767	+ 33	+ 113
Michigan	505,646	8,851,361	611,446	18,300,501	+ 105,800	+ 9,449,140	+ 21	+ 107
New Jersey	*	*	187,758	6,618,536	†	†	†	†
New York	2,289,608	40,587,240	2,276,367	52,318,661	— 13,241	+ 11,731,421	— .6	+ 29
Ohio	8,689,030	136,855,228	8,469,052	231,165,093	— 219,978	+ 94,309,865	— 3	+ 69
Pennsylvania	16,351,131	293,437,782	15,423,262	460,677,474	— 927,869	+167,239,692	— 6	+ 57
Tennessee	329,342	4,981,538	346,638	9,102,441	+ 17,296	+. 4,120,903	+ 5	+ 83
Virginia	444,491	7,140,002	562,299	15,708,295	+ 117,808	+ 8,568,293	+ 26	+ 120
Wisconsin	423,973	7,584,327	402,732	11,082,274	— 21,241	+ 3,497,947	-- 5	+ 46
Other states‡	3,418,770	54,786,071	3,711,041	87,981,078	+ †480,024	+†39,768,548	+ †14	+ †73
	39,126,324	668,478,118	38,612,546	1,058,785,975	— 513,778	+390,307,857	— 1.3	+ 59

*Included with "Other States."

†Increase in New Jersey included in "Other States."

‡1916: California, Colorado, Connecticut, Indiana, Maryland, Massachusetts, Minnesota, Missouri, New Jersey, and West Virginia. 1917: Colorado, Connecticut, Georgia, Indiana, Maryland, Massachusetts, Minnesota, Missouri, Washington, and West Virginia.

AVERAGE PRICES.

The average price per gross ton of all kinds of pig iron, by states, from 1912 to 1917, given in the following table is based on reports of the manufacturers to the Survey. These figures represent the approximate prices f. o. b. at the blast furnaces and do not include the prices of ferroalloys.

The general average prices for 1916 and 1917 appear low for such active years in the iron industry. At the close of 1916 market prices of pig iron were between 45 and 68 per cent higher than at the beginning of the year, but this increase was confined almost entirely to the last two or three months of the year, so that the average increase in price was only 28 per cent as compared with 1915. In 1917, however, the course of prices was very different, for at the beginning and end of the year prices were more nearly the same with the high levels at the middle of the year. The curve of markept price of basic iron at Valley furnaces reflects this unusual condition. The general average prices for all grades of pig iron at the furnaces, exclusive of ferroalloys, for the year 1917 was $27.29, as compared with $16.96 in 1916, an increase of $10.33 a ton, or nearly 61 per cent. The states in which the average selling price of pig iron was more than $30 a ton were Connecticut, Georgia, Massachusetts, Missouri, New Jersey, and Washington.

Average price per gross ton of pig iron in the United States, 1912 to 1917.

STATE	1912	1913	1914	1915	1916	1917
Alabama	$10.75	$12.08	$10.52	$10.24	$14.59	$21.64
Illinois	15.26	15.83	13.59	13.93	17.57	26.34
Kentucky	15.74	16.09	12.24	13.44	17.97	28.78
Michigan	14.30	14.69	13.78	13.63	17.51	29.93
New Jersey	*	*	*	*	*	35.25
New York	14.22	15.35	14.26	14.02	17.70	22.98
Ohio	13.07	15.02	13.46	12.96	15.75	27.30
Pennsylvania	14.60	15.36	13.78	13.69	17.95	29.87
Tennessee	12.29	13.22	12.05	12.09	15.13	26.26
Virginia	13.27	13.96	12.53	12.83	16.06	27.93
Wisconsin	14.33	15.13	13.35	13.20	17.77	27.39
Other states†	14.07	15.50	13.55	12.96	16.08	24.25
Average for United States	13.93	15.08	13.42	13.21	16.96	27.29

*Included in "Other States."

†1911: California, Colorado, Connecticut, Georgia, Indiana, Maryland, Massachusetts, Minnesota, Missouri, New Jersey, and West Virginia; 1912 and 1913: California, Colorado, Connecticut, Indiana, Maryland, Massachusetts, Minnesota, Missouri, New Jersey, and West Virginia; 1914: California, Colorado, Connecticut, Indiana, Maryland, Massachusetts, Minnesota, Mississippi, Missouri, New Jersey, and West Virginia: 1915: Colorado, Connecticut, Indiana, Maryland, Massachusetts, Minnesota, Missouri, New Jersey, and West Virginia; 1916: California, Colorado, Connecticut, Indiana, Maryland, Massachusetts, Minnesota, Missouri, New Jersey, and West Virginia; 1917: Colorado, Connecticut, Georgia, Indiana, Maryland, Massachusetts, Minnesota, Missouri, Washington, and West Virginia.

BLAST FURNACES.

The number of furnaces in blast on June 30 and December 31 and the total number of stacks recorded for the years 1916 and 1917, not including any electric reduction furnaces, as published by the bureau of statistics of the American Iron and Steel Institute, are as follows:

Blast furnaces in the United States, 1916 and 1917.

STATE	Furnaces in blast June 30, 1916.	Dec. 31, 1917			Furnaces in blast June 30, 1917.	Dec. 31, 1917		
		In.	Out.	Total.		In.	Out.	Total.
Pennsylvania	132	127	30	157	186	122	41	163
Ohio	67	65	12	77	72	64	15	79
Illinois	28	24	0	24	22	18	7	25
Alabama	31	29	18	47	34	34	13	47
New York	20	18	9	27	21	21	4	25
Virginia	9	9	13	22	12	15	4	19
Tennessee	12	11	7	18	12	10	6	16
Colorado	4	3	3	6	4	3	3	6
Missouri	1	2	0	2	2	2	0	2
Oregon	0	0	1	1	0	0	1	1
Washington	—	—	—	—	0	0	1	1
California	0	0	0	0	0	1	1	1
Maryland	4	4	1	5	4	2	3	5
New Jersey	1	1	4	5	4	5	0	5
Wisconsin	6	5	3	8	6	5	3	8
Minnesota	3	3	0	3	3	3	0	3
Indiana	10	10	0	10	12	13	1	14
Michigan	12	12	2	14	12	12	2	14
West Virginia	4	4	0	4	4	3	1	4
Kentucky	4	4	2	6	4	4	3	7
Georgia	0	0	4	4	0	1	3	4
Texas	0	0	2	2	0	0	2	2
Mississippi	0	0	1	1	0	0	1	1
Connecticut	0	1	2	3	2	2	1	3
Massachusetts	1	1	1	2	1	1	1	2
	344	333	115	448	367	340	117	457

LIME.

DURING the year 1917 there was a decrease in the production of lime in Alabama, as compared with the production of the preceding year. The total product of 10 plants in 1917 was 66,744 short tons, a decrease from 1916 of 780 tons, or 1.2 per cent.

The value of the product was $383,211, an increase of $70,680 or 22.6 per cent.

The most important use of the lime produced was for building purposes, 60.5 per cent of the product is definitely so credited in the returns while the greater part of the lime sold to dealers and most of the hydrated lime go to building purposes. Other chief uses of lime are in chemical works, paper mills, sugar factories, agriculture, tanneries, slag cement, etc.

Shelby County, as heretofore, was the largest producer in 1916, being credited with 52,809 tons or 78.21 per cent of the total. The other producing counties in the order of their importance are Blount and Jackson.

The following tables give some additional data on the lime production in Alabama in 1916 and 1917.

For a full account of the lime industry in the United States, those interested are referred to the article on Lime, by G. F. Loughlin, in "Mineral Resources of the United States, 1917."

Lime burned and sold in Alabama in 1916 and 1917.

YEAR	Rank of state by quantity	Quantity (short tons)	Value	Rank of state by value	Average price per ton	Number of plants in operation
1916	16	67,524	$312,531	23	$4.63	9
1917	16	66,744	383,211	17	5.74	10
Incr'se or decrease		— 780	+ 70,680		+ 1.11	
Percentage		— 1.2	+ 22.6		+ 24.0	

Lime sold in Alabama in 1916 and 1917, by uses.

	Quantity (short tons)	Value	Average price per ton U. S.
1916			
Building lime	7,744	$33,069	$5.21
Chemical works	703	2,571	3.70
Paper mills	†	†	4.14
Sugar factories	....	....	5.41
Tanneries	†	†	4.64
Agriculture	592	2,246	3.68
Dealers, uses not specified	50,007	243,582	4.95
Other uses, and undistributed	3,478	31,063	....
Total	67,524	$312,531	$4.54
1917			
Building lime	40,336	287,410	$6.63
Chemical works	3,222	16,503	5.79
Paper mills	7,660	35,968	5.65
Sugar factories	1,210	7,459	8.08
Tanneries	†	†	6.14
Agriculture	1,791	9,816	5.07
Dealers, uses not specified	11,290	69,879	6.42
Other uses and undistributed	†	†	9.09
Total	66,744	383,211	6.29
Percentage of increase or decrease in 1917	— 1.2	+ 22.6	....
Hydrated lime (included in total), 1916	6,780	36,864	....
Hydrated lime (included in total), 1917	6,541	48,089	....
Increase or decrease of hydrated lime in 1917	— 239	+ 11,225	....
Percentage of increase or decrease of hydrated lime in 1917	— 3.63	+ 30.6	....

Lime consumed in Alabama in 1917.

LIME, 1917					Consumption of Lime per capita (short tons)		
	Consumed						
Produced (short tons)	Quicklime (short tons)	Hydrated lime (short tons)	Shipped out of State (short tons)	Shippd into State (short tons)	1916	1917	Population in 1917 (estimated)
66,744	20,026	2,895	47,426	3,603	0.01	0.01	2,363,939

Number of lime kilns in Alabama using various kinds of fuel in 1916 and 1917.

	Coal	Wood	Oil	Natural gas	Producer gas	Coke	Shavings	Coal and Wood	Coal and Coke	Total
1916	7	6	—	—	—	—	—	20	—	33
1917	4	1	—	—	—	—	—	12	—	17

KILNS.

By W. E. EMLEY.

The accompanying table contains evidence of a certain amount of confusion in the common usage of the names applied to different types of limekilns. It was thought advisable to include kilns called "shaft," "vertical," "continuous," or "gas" in the column headed "flame or patent kilns," assuming these all to be different names for the same thing. It is possible that this assumption may be incorrect.

In order to avoid such confusion in the future, and for the broader purpose of establishing a system of nomenclature within the industry, the following definitions of the different types of kilns are suggested:

A "field" kiln is distinguished from all other types by being intermittent in its operation. Firing is continued until the contents of the kiln are calcined, when the kiln is entirely emptied. Under some conditions it may be demolished and rebuilt after each burn. A "continuous" kiln is a kiln of any type other than a field kiln.

A "pot" kiln is a vertical shaft kiln which is continuous in its operation. Its peculiar characteristic is that the fuel and stone are charged into the kiln in alternate layers.

A "flame" kiln is a vertical kiln which is continuous in its operation. Its name is derived from the fact that only the flame of the fuel and not the fuel itself comes into contact with the stone or lime. This type is sometimes known as a "patent" kiln, but the term "flame" is to be preferred as more significant.

A "rotary" kiln needs no description.

The term "gas kiln" is to be avoided in this connection because it indicates the kind of fuel rather than the type of kiln.

Capacity and kind of lime kilns used in Alabama in 1917.

Capacity (short tons per day)	Pot	Flame	Rotary	Field and Unspecified	Total
317	9	14	————	————	23

MICA.

By **Waldemar T. Schaller.**

INTRODUCTION.

MICA is used in the form of sheet mica, splittings, and ground mica. The uncut sheet of smallest practicable size, known as punch mica, should yield a disk or washer at least 1½ inches in diameter if the mica is stained and 1¼ inches in diameter if the mica is clear. The smallest "plate sheet" should yield a rectangle at least 1½ by 2 inches. Sheet mica is used in various sizes, chiefly for insulation in electric appliances, for glazing the fronts of stoves, for lamp chimneys and shades, and for phonograph diaphragms. Both domestic and foreign mica are used for these purposes. For certain high-potential electric appliances only a high-grade mica free from inclusions, cracks, pin holes, or other defects, can be used.

Splittings or films are very thin sheets of mica, about a thousandth of an inch thick. These are manufactured into built-up mica boards, such as micanite, micabeston, micabond, and micadamite. No appreciable quantity of splittings or films of domestic mica is sold, practically the entire supply of splittings consumed in the manufacture of mica board being imported. This built-up mica board is largely used in electric insulation.

Ground mica finds its chief applications in the manufacture of patent roofing, in the annealing of steel, in lubrication, and in decoration. These and other uses are described in detail below. Although some ground mica is imported, the bulk of such mica consumed, about 96 per cent, is of domestic origin. Mica has been estimated to constitute about 4 per cent of all igneous rocks, and as no special property is required of mica suitable for grinding, it is evident that any desired quantity of ground mica can be produced in this country.

The requirements for sheet mica to be used in the industries are very particular, and only a very small percentage of the total mica extracted can finally be utilized as sheet. The specifications for mica to be used in high-potential appliances, such as are used in wireless apparatus and in airplanes and automobile trucks, are very rigid.

Owing to the restrictions imposed on the importation of mica the question has arisen whether the entire demand of the country can be supplied by the domestic production. This question can not be definitely answered at present, but there seem to be grave doubts as to the domestic output being sufficiently increased.

The sheet mica imported from India has been largely used in many industries in this country and has been generally found to give very satisfactory results. Much of the domestic mica produced is said to be unfit for many of the purposes to which Indian mica is applied. An inquiry as to the possibility of domestic mica replacing imported Indian mica must have reference to the quality of the domestic mica and the quantity of suitable material which can be produced. Several large users have stated that this country contains deposits of mica which is fully as good as the Indian mica.

For the 18-year period 1900-1917 the proportion of the consumption of sheet mica (including splittings) represented by domestic production has averaged about 38.5 per cent, with extreme variations of 14 per cent in 1902 and 64 per cent in 1908. The average for 1900-1913 was 38 per cent. For the years 1903-1907, 1909, and 1912-1917 the percentages lay between 30 and 50. For the war years the percentages have shown very little change, being 41 for 1914, 40 for 1915, 40 for 1916, and 42 for 1917. In other words, there has been very little change in the ratio of domestic production to consumption of sheet mica since 1913. This ratio shows a decrease, however, as compared with the years immediately preceding 1914, except 1912, for the percentages were 44 for 1913, 30 for 1912, 59 for 1911, 56 for 1910, 49 for 1909, and 64 for 1908. For the years 1900 to 1907 the percentage was lower than 38 each year.

PRODUCTION.

The domestic production in 1917 came from eight states, which, grouped in the order of quantity of sheet mica produced, are North Carolina, New Hampshire, Virginia, South Dakota, Georgia, Alabama, Idaho, and Colorado. As in previous years, North Carolina led all other states both in quantity and in value of mica produced.

Percentage of production of mica in 1917, by States.

STATE	Quantity		Value
	Sheet	Scrap	
North Carolina	48	67	70
New Hampshire	39	20	23
Virginia	6	8	3
South Dakota	3	5	1
Georgia	4	—	3
Alabama			
Idaho and Colorado			
	100	100	100

The annual production of mica in Alabama for the years 1912-1917 is shown in the following table. Where less than three producers reported returns, the figures are omitted, so that no individual production is disclosed. For several years, therefore, the figures of production can not be given.

[illegible]

[illegible]

Year	[illegible]	[illegible]	Value	[illegible]	Value	Total quantity	Total value
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	236	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	661	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]

PRICES.

Average prices per pound paid in the South for rough-trimmed sheet mica of good quality, split and sorted to cut the sizes indicated, 1913–1917.

SIZE (IN INCHES)	1913	1914	1915	1916	1917
Punch	$0.035	$0.03	$0.04	$0.05	$0.055
1½ by 2	.12	.10	.20	.30	.40
2 by 2	.30	.25	.40	.55	.70
2 by 3	.70	.65	.70	.90	1.10
3 by 3	1.15	1.00	1.00	1.35	1.55
3 by 4	1.35	1.20	1.25	1.70	1.85
3 by 5	1.70	1.50	1.50	1.95	2.15
4 by 6	2.25	2.00	2.10	2.85	3.10
6 by 6	3.00	2.70	2.80	3.50	3.80
6 by 8	4.00	3.60	3.50	5.00	4.70
8 by 10	6.00	5.40	5.20	7.50	7.50

Average prices paid in the South per pound for rough-trimmed sheet mica, split and sorted to cut the sizes and qualities indicated, December, 1917–January, 1918.

SIZE (IN INCHES)	Good quality	Slightly spotted, or clay-stained	Heavily spotted or clay-stained
Punch	$0.07	$0.06	$0.05
1½ by 2	.45	.35	.20
2 by 2	.80	.65	.35
2 by 3	1.25	1.00	.65
3 by 3	1.60	1.40	.90
3 by 4	1.90	1.60	1.20
3 by 5	2.25	1.90	1.40
4 by 6	3.25	2.50	1.75
6 by 8	5.00	3.75	2.25

USES.

The different uses to which mica is put depend on its form—whether in sheets or in powder. Sheet mica is used in the electrical industry, for glazing, and to some extent for other purposes. Ground mica is used chiefly in the decorative trades, for annealing, for lubrication, and in patent roofing.

Sheet mica finds its greatest use in the electrical industry, where an insulating, noninflammable material is necessary. It is used in sheets and as washers and disks in dynamo-electric machinery, electric-light sockets, spark plugs, insulators, guards in rheostats, fuse boxes, and telephones. Flexible cloth and tape, covered with mica, find varied uses in electrical apparatus. Sheet mica is used for glazing the fronts of stoves, for furnace sight holes, for screens in front of highly heated material, for optical lanterns as a retarder of heat waves, and for making lamp chimneys and lamp shades. It is also used in spectacles (amber-colored phlogopite* would seem to be the ideal material for goggles in oxy-actelylene welding), motor goggles, sand blasting, sight holes of divers' helmets and smoke helmets, compass cards, automobile shields, phonograph diaphragms, in windows where glass would be broken by heavy shocks or by vibrations as in the conning towers of warships and of submarines, and in lantern transparencies.

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*Thin sheets of phlogopite, if of suitable clearness and color, afford very great relief to the eyes in glaring sunlight and seem to make objects more clearly visible.

A peculiar silvery mica is used in India for inlay work. In India also pictures and portraits in large numbers are painted on sheets of mica.

Sheet mica has come to be of importance as a war mineral through its use as insulator in electric apparatus, especially in condensers, magnetos, and spark plugs; also as windows in masks worn for defense against asphyxiating gases, and for other uses where a transparent, noninflammable, nonshattering material is necessary, as in automobile goggles and as coverings for wounds.

Ground mica is used for decoration in wall paper, to which it gives luster and brightness; in fancy paints, ornamental tiles, concrete, rubber goods, pipe and boiler coverings, insulating compounds, fire-proof paints and coverings, patent roofing material, molded mica (ground mica mixed with shellac), and calico printing; as absorbent for nitroglycerin in the manufacture of "mica powder;" in annealing steel; to a large extent as a lubricant for wooden bearings, or, mixed with oil, as a lubricant for wooden bearings, or, mixed with oil, as a lubricant for metal bearings; in the manufacture of automobile treads on new tires, as well as in repair stock; and as a filler for various other products. Tar and other roofing papers are coated with coarsely ground mica to prevent sticking when they are rolled for shipment. A possible value of ground mica as a chemical source of potash salts has been suggested, especially its direct application to the soil as a fertilizer.

A recently patented insulating material,† claimed to be hard and almost incombustible, is composed of 14 per cent sifted mica, 52 per cent pulverized asbestos, 20 per cent mineral caoutchouc, 10 per cent rubber solution, 3 per cent sulphur, and 1 per cent resin. The material can be molded and wrought and can be used as a substitute for porcelain, marble, slate, and vulcanized substances.

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†Jour. Indust. Eng. Chemistry, vol. 10, p. 314, 1918.

In India ground mica is used for processional ornaments, such as lamps, pottery, curtains, cloth, and tinsel decorations on fans, and in buildings, especially in temples and palaces. Large quantities have also been employed for medicinal uses—an application which has not extended beyond its country of origin.

Several trade names have been given to the mica products described below.

Micalite is applied by Eugene Munsell & Co., 68 Church Street, New York, N. Y., to the mica used in mica chimneys, candle shade protectors, and canopies.

Micanite is a term applied by the Mica Insulator Co., of Schenectady, N. Y., to a manufactured mica board or plate, built up by successive layers from many small thin films of mica, which, after being dipped into and cemented with shellac, are then subjected to pressure under heat to dry out the shellac. These large sheets are then milled to the requisite thickness and made suitable for many electrical purposes.

Micabeston, which is similar to micanite, is manufactured by the American Mica Co., of Newton Lower Falls, Mass. Several varieties are made, one of which becomes flexible when heated and rigid when cold, and is used for insulation in field coils, transformers, armatures, etc., where high heat is not generated, another variety remains rigid under a high heat and is used in commutators of generators and motors.

Micabond, made by the Chicago Mica Co., of Valparaiso, Ind., is also similar and is made in varying qualities with different properties, depending on its use.

Micadamite, manufactured by Mierowsky Bros., 106-108 Broadway, Jersey City, N. J., is similar built-up micaplate, manufactured into rings, tubes, segments, and many other forms of insulation.

These manufactured mica sheets use a number of different substances as binders in addition to shellac, chiefly paper of various grades (Japan tissue, manila, rope, fish), muslin cloth, rubber, and gutta percha.

Silberglimmer (silvery mica) is muscovite which has been heated to a sufficiently high temperature to make it softer and opaque and silvery in appearance. It is also known as annealed mica and finds a use in certain parts of electric apparatus.

Rimco is mica ground by a nonmetallic process by the Richmond Mica Co., Richmond, Va., for use as a tire powder. It is also used by manufacturers of oils and lubricating greases.

Micamima, prepared by the Crawford Mica Co., of Crawford, Nebr., is a coarsely ground mica used in the manufacture of concrete facing material; mixed with other minerals it is used to give the effect of natural rock, and it may be used for different decorative purposes.

Micolith, or micholithic, prepared by the Texas Mica Co., of Pecos, Tex., is another similar product used to give the effect of natural rock to concrete facings.

Tungash, as the Denver Mining & Manufacturing Co., of Denver, Colo., calls its product, is a bronze-colored, metallic-looking material of value for decoration. The crude biotite mica, altered and hydrated, has a dull greenish-black appearance when mined. On being heated it expands to a light product, which has a rich golden-bronze color and a decidedly metallic luster.

Clinomica is the name given by the America Mica Co., 52 Broadway, New York, to its ground clinochlore, a micaceous mineral of the chlorite group. Clinomica possesses essentially the qualities of ground mica and is used as a dusting material in the rubber and composition-roofing industries, for paints, cements, lubricants, molded electric insulation, and as a filler for various products.

MINERAL WATERS.

By Arthur J. Ellis.

Character of Statistics.

THE statistics given in this report have been compiled from individual reports furnished by the owners or operators of springs and include, so far as can be ascertained, only natural waters that are bottled and sold in their natural state or only slightly altered from their natural state. Natural still waters that have been artificially carbonated, natural carbonated waters that have lost part of their carbon dioxide, and waters from which iron has been removed are included; but artificial waters and natural waters that have been flavored, concentrated, fortified, diluted, or otherwise essentially modified in chemical character are excluded if available information indicates such treatment. Water given away or consumed at spring resorts, which constitutes a large part of the annual production, is excluded. Waters sold at flat or meter rates, delivered to consumers through pipes, or otherwise obviously municipal supplies or adjuncts to them are excluded. This is the nearest practicable conformity with the commonly accepted definition of natural mineral water. No distinction is made between mineral water flowing or pumped from a natural spring and that flowing or pumped from a dug, bored, driven, or drilled well. Many of the best-known mineral waters in the United States come not from natural springs but from wells.

Distinction for statistical purposes between table and medicinal waters is entirely arbitrary. Most table waters are clear, sparkling, and without distinct mineral taste or odor; many medicinal waters are highly mineralized and have distinct mineral taste and odor. Yet some table waters are more strongly mineralized than some medicinal waters, and many medicinal waters contain less mineral matter than certain city supplies. The basis here used for distinguishing medicinal from table waters is the report regarding the spring, and this distinction is based in turn on the operator's knowledge that some of his customers buy the water to use regularly on their tables and others buy it for an aid during illness. A few strongly mineralized waters are not sold as table waters, and a few widely sold table waters are not used medicinally, but many waters are sold for both uses, though the reported sales of several medicinal waters have distinctly decreased in the last few years.

MINERAL WATER TRADE IN ALABAMA, 1917.

Returns from Alabama indicate that the mineral-water trade in 1917 was about 46 per cent less than it was in 1916. The sales amounted to 56,270 gallons, and the value of the output was $5,509, the average price per gallon decreasing from 12 cents to 10 cents. There was a considerable decrease in the value of the output of table waters, from $6,195 to $2,072. Two springs which were active in 1916 reported no sales for 1917; one which was active in 1916 was not heard from, and another, from which no report was received, was estimated. Three mineral-water bathing establishments and 5 resorts, accommodating about 500 guests, were maintained. The quantity of mineral water used in the manufacture of soft drinks decreased from 13,500 gallons to 1,227 gallons.

The following 13 springs reported sales:

Bladon Springs, Bladon Springs, Choctaw County.
Blount Springs, Blount Springs, Choctaw County.
Cooks Springs, Cooks Springs, St. Clair County.
Dixie Springs, Dixie Springs, Walker County.
Gordon Mineral Springs, Canoe, Escambia County.
Healing Springs, Healing Springs, Washington County.
Livingston Mineral Well, Livingston, Sumter County.
Luverne Mineral Spring, Luverne, Crenshaw County.
McCary Mineral Well, near Birmingham, Jefferson County.
Matchless Mineral Water Well, east of Greenville, Butler County.
Purity Spring, Spring Hill, Mobile County.
Shocco Springs, Talladega, Talladega County.
White Sulphur Wells, near Jackson, Clarke County.

The following tables add some details to the general statements above given:

Mineral waters sold in Alabama in 1916 and 1917.

YEAR	Commercial Springs	Quantity Sold (gallons)	Average price per gallon (cents)	Value of medicinal waters	Value of table waters	Total value
1916	16	103,944	12	5,979	6,195	12,174
1917	13	56,270	10	3,437	2,072	5,509

Comparative production of mineral waters in Alabama in 1916 and 1917.

YEAR	Commercial Springs	Quantity sold (gallons)	Value of product
1916	16	103,944	$12,174
1917	13	56,270	5,509
Decrease	— 3	— 47,674	— 6,665
Percentage of decrease	— 18.7	— 46.8	— 54.7

A comparison of American and European mineral waters, by Alfred A. Chambers, is given in "Mineral Resources of the United States, Part II, pages 500-508." A discussion of the waters of Alabama, may be found in a report of the Geological Survey of Alabama, "Underground Waters of Alabama," by Eugene A. Smith, State Geologist, 1907.

PYRITES.

QUALITIES AND USES.

THE term pyrites is the indefinite general trade name for any of the iron sulphide minerals, such as pyrite, marcasite, and pyrrhotite. Pyrite and marcasite when pure have identical chemical composition, namely, about 53 per cent sulphur and 47 per cent iron, but differ from each other in mode of crystallization. Pyrite forms cubical crystals, whereas marcasite forms tabular crystals. Pyrrhotite when pure contains about 40 per cent sulphur and 60 per cent iron, it is somewhat softer, tarnishes more readily than either pyrite or marcasite, and is magnetic, whereas the other minerals are not.

Pyrites is used mainly for the manufacture of sulphuric acid, and more than 1,250,000 long tons is consumed each year for this purpose. Pyrites, as commercially used, is generally referred to one of two classes, lump or fines. The lump ore, as its name implies, consists of pieces more than half an inch in diameter, with a certain allowable proportion of smaller particles, and is used in the condition in which it comes from the mine with little more than a preliminary crushing and sorting according to size. The fines consist of smaller particles and generally have been obtained by crushing the ore so small that the pyrites can be separated from worthless gangue by some mechanical process. They are also derived from ore that has disintegrated as a result of leaching. Owing to the different methods of treating these two kinds of pyrites for the extraction of their sulphur, they can not be used interchangeably. The lump ore commands somewhat higher prices than the fines, but, of course, it is more difficult to obtain a lump ore with as high a sulphur content as that of fines. As a result, only a few mines or parts of a mine can furnish lump ore and maintain a sufficient sulphur content, whereas suitable fines may be obtained even from deposits in which the pyrites is sparsely disseminated.

No definite lower limit can be placed on the proportion of sulphur that a pyritic ore must contain to be of commercial grade. In practice, however, material containing more than 40 per cent of sulphur is specified, and practically none of the acid companies use material that carries less than 35 per cent of sulphur.

Several elements or substances by no means rare in pyritic ores are objectionable as material to be used in the manufacture of sulphuric acid and decrease the value of the ore in which they occur, or they can be used only by means of special treatment.

Certain elements, arsenic and antimony for instance, are poisonous and have a bad effect on the resulting acid, but some of the large fertilizer plants do not reject an ore containing less than 1 per cent of arsenic. These elements are also injurious from a manufacturing standpoint if the pyrites is used in plants making acid by the contact process, as they attack the platinum and cause it to lose its efficiency. According to Wilson,* pyrites carrying more than 8 per cent of copper can not be profitably employed in the manufacture of sulphuric acid. Carbonaceous material, such as the coal adhering to the pyrites or "coal brasses," is apparently heavily penalized by acid manufacturers because it yields acid of a dark color. This effect, however, should not prevent pyrites containing some material of this sort being used in making some low-grade acids for the manufacture of fertilizers and similar materials. On the other hand, however, most of the pyrites derived from the coal beds is marcasite, which decomposes readily, sometimes ignites through spontaneous combustion, or oxidizes to sulphuric acid, and is therefore a dangerous or expensive substance to leave in storage dumps.

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*Wilson, A. W. G., Pyrites in Canada: Canada Dept. Mines, Mines Branch, Pub. 167, p. 22, 1912.

CONDITION OF THE INDUSTRY.

The pyrites industry throughout 1917 showed an unsettled condition due largely to uncertainty as to whether importation of foreign pyrites would be continued. At times the impression would be prevalent that further imports of pyrites would be stopped and there would follow a feverish interest in finding possible sources of domestic ore. Before much progress had been made in this search, however, a contrary rumor would be circulated and activities would decrease or actually stop. These conditions alternated in their hold on the minds of those who might have been willing to undertake the rather expensive and time-consuming operation of developing mines capable of supplying the sulphuric-acid industry with pyrites. Because of this uncertainty some of the former users of imported pyrites decided to replace it with sulphur and thus reduce the quantity of imported ore required. This substitution required little change in technology in many of the plants and it was adopted by many manufacturers. By the last part of the year, however, it became evident that more domestic pyrites was necessary, and consequently several mines were opened. It takes time, however, to bring a pyrites mine to the producing stage, so that this activity had but little effect on the output of pyrites in 1917, but it will probably have a considerable effect on the output in 1918.

The shortage of pyrites was made evident by the high price that was paid for it and the difficulty of obtaining considerable quantities even at prices three times those paid in 1916. The quotations given for pyrites in the technical press in 1917 range all the way from 20 to 35 cents a unit for the sulphur content. On the assumption that the pyrites carried 45 per cent sulphur, the latter price would bring a return of $15.75 a ton for the pyrites. The usual pre-war price of prites was less than $4 a ton, and according to the statistics published by the Geological Survey the average price per ton even in 1916 was $4.64.

Pyrites produced in United States in 1917.

	Quantity (long tons	Value		Quantity (long tons	Value
California	115,817	$338,501	Virginia	170,382	$1,378,043
Georgia	23,242	155,560	Other states*	115,407	498,776
Illinois	24,596	89,998			
Ohio	13,218	29,557		462,662	2,485,435

*Includes Alabama, Indiana, Kentucky, Missouri, New York, Pennsylvania, South Dakota, Tennessee, and Wisconsin.

PRODUCTION IN ALABAMA.

In 1917 there were three producing pyrites mines in Alabama—those of the National Pyrites & Copper Co., the Southern Sulphur Ore Co., and the L. M. Mining Association. All three of these mines are in the east-central part of the State, in Clay County, near Pyriton. Deposits in this region have been known for some time, but the mines were reopened during 1917, and by the end of the year the first two were producing a considerable quantity of pyrite.

The deposit at the National Pyrites & Coppehr Co.'s mine, formerly owned by the Alabama Sulphur Ore & Copper Co., is in schist and consists of irregular lenses, some of them 300 feet long and 35 feet thick. The deposit has been opened by an incline of about 30° slope for a distance of 450 feet, and the average grade of ore shipped is reported to carry about 40 per cent sulphur. Both lump and fines are shipped. The ore also carries about 1 per cent copper.

The conditions at the property of the Southern Sulphur Ore Co.'s mine are essentially the same as at the National Pyrites & Sulphur Co.'s mine, and both lump and fines, containing about 40 per cent of sulphur, are shipped.

The L. M. Mining Association has leased the old Mattison mine, about 2 miles from Pyriton. The ore body is reported to have an average thickness near the surface of about 8 feet, but this decreases in depth so that at the bottom of the shaft, which is 135 feet deep, it is only about 2 feet thick. The ore is reported to have an average content of 42 per cent of sulphur and more than 2 per cent of copper.

All three of these mines report great difficulty in getting an adequate supply of suitable labor. It is estimated that possibly during 1918 they may have a combined production of 25,000 tons.

The general belt in which the ore bodies described occur extends for a considerable distance beyond the area prospected and seems to be worth further investigation. In Coosa County, on Hatchet Creek near Bull Gap, and at the old McGhee gold mine, some pyritic ore has been mined in the past, and probably a small quantity could be quickly obtained if required and possibly a considerable output if systematic exploration and development were undertaken. According to the State geologist of Alabama, however, the pyrites at the Hatchet Creek locality is in irregular concretionary masses and consequently is probably of rather small extent.

A large deposit of what appears to be bedded limonite derived from pyrites is reported in Shinbone Valley, 10 to 15 miles northeast of Pyriton. This appears to be a gossan and if so it is worth testing with the drill, as the indications point to a considerable deposit of pyrites beneath it. W. S. Harper, of Wedowee, Ala., owns some of the properties on which this deposit occurs. Near Stonehill, in Cleburne County, in the vicinity of the Woods copper mine, are two deposits of pyrrhotite and pyrite. The ore is in general similar to that in the Ducktown district, Tenn., and the deposit at one of the localities is said to have been traced more or less continuously for a distance of 1,200 feet. An analysis of the ore is reported to have shown a content of slightly more than 30 per cent of sulphur.

Numerous reports have been received of indications of pyrites all the way from Chilton County west of Coosa River northeastward to the Georgia-Alabama State line, but details concerning promising localities are not at hand. Some pyrites has been reported near Gold Branch, in Coosa County, also along the eastern flanks of Talladega Mountain, at the old Hog Mountain gold mine, where a vein of pyrites 10 to 15 feet thick has been reported. H. D. McCaskey, of the United States Geological Survey, also noted an apparent gossan at least 30 feet wide and possibly 50 feet wide on the south flank of Horseblock Mountain near the Chulafinnee-Abel road. This type of material trends about east and west and outcrops of it or of similar deposits have been recognized for a distance of about 2 miles. The eastern outcrop has been prospected for copper in the past but without success.

SILICA.

SILICA was produced by one firm operating at Tredegar, Calhoun County, Alabama, in 1917. The material quarried is a soft siliceous residue somewhat like the tripoli mined in Missouri and Illinois.

SAND AND GRAVEL.

THE total production of sand and gravel in the State in 1917 was 476,678 short tons, valued at $222,011, as compared with 726,650 tons, valued at $184,216 in

1916, a decrease in quantity of 249,972 tons, or 34.2 per cent, and an increase in the value of $37,795, or 20.3 per cent.

There was a decrease in the quantity of sand of 272,044 short tons, or 43.2 per cent, and in the value of $8,277, or 5.59 per cent.

There was an enormous increase in the production of gravel. The increase in quantity was 22,072 short tons, or 22.7 per cent, and of $46,072, or 126.1 per cent in value. This increase was probably due to the construction of war-time cantonments, military highways and railroads, and other war necessities. Ordinary building operations were much less in 1917 than in 1916.

Moulding and building sands made up 64.0 per cent of the sand production; moulding 32.7, building 31.3 per cent. There was a marked falling off of the production of railroad ballast, decreasing from 41.58 in 1916 to 2.66 per cent in 1917.

The following tables give a comparison of the production of sand and gravel in 1916 and 1917, and the production, value and kinds of sands in these two years.

Production in short tons of sand and gravel in Alabama in 1916 and 1917.

	SAND		GRAVEL		Total'		Percentage of U. S. total
	Quantity	Value	Quantity	Value	Quantity	Value	
1916	627,577	147,952	99,073	36,264	726,650	184,216	0.62
1917	355,533	139,675	121,145	82,336	476,678	222,011	0.63
Increase or decrease	—272,044	— 8,277	+ 22,072	+46,072	—249,972	+37,795	——
Percentage	— 43.2	— 5.59	+ 22.7	+ 126.1	— 34.2	+ 20.3	——

Quantity (short tons), value and kind of sand produced in Alabama in 1916 and 1917.

	Moulding Sand		Building Sand		Paving Sand		Engine Sand		Grinding and Polishing Sand		Railroad Ballast Sand and Gravel		Other Sands		Total	
	Quantity	Value	Quantity	Value	Quantity	Value	Quantity	Value	Quantity	Value	Quantity	Value	Quantity	Value	Quantity	Value
1916	131,312	41,470	220,336	66,989	*	*	6,199	1,741	*	*	259,957	$32,413	*	*	627,577	147,952
1917	148,355	54,742	157,107	67,277	*	*	*	*	*	*	12,690	3,014	*	*	476,678	222,011
Increase+ or Decrease—	+17,043	+13,272	—63,229	+ 288	—	—	—	—	—	—	-247267	-29,399	—	—	—150,899	+74,059
Percentage	+ 1.29	+ 32.6	— 27.9	+ 0.43	—	—	—	—	—	—	— 95.3	— 90.7	—	—	— 25.4	+ 50.0

*Concealed because of less than three producers.

STONE.

EUGENE A. SMITH.

ON ACCOUNT of the variety of uses to which stone is put, there is no regular unit of measurement, and the figures in this report represent the values of the different varieties.

PRODUCTION.

Alabama produces only three kinds of stone, viz., limestone, marble and sandstone.

The total value of the stone produced in Alabama shows an increase in 1917 of 34.0 per cent. The greater part of this increase was in the limestone, (rough and dressed building stone, and furnace flux). There was a notable decrease in the sandstone, while the production of marble showed 16 per cent increase in value. Alabama ranked fourth among the marble-producing states in 1917, whereas it ranked seventh in 1916.

Exact figures for marble, however, cannot be given as there were in 1916 as well as in 1917 only two producers.

The following table gives some additional details of the total stone production.

Total value of stone (limestone, sandstone and marble) produced in Alabama in 1916 and 1917. Percentage of total U. S. value, rank of State and number of plants.

Year	Total Value	Percentage of total U. S. value	Number of Plants	Rank of State
1916	$1,202,256	1.52	25	20
1917	1,611,497	1.96	29	19
Increase in 1917	409,241	—	—	—
Percentage	34.0	—	—	—

LIMESTONE.

The most important use of limestone produced in Alabama in 1917 as in 1916, was for furnace flux, while crushed stone for concrete follows next in importance. For the other uses given in the table the value of the limestone shows a decrease, notably in the case of riprap.

The limestone burned into lime or used in the manufacture of Portland cement is not taken into account here, but is included in the value of each of the finished products in whose manufacture it was used.

As thus limited the total value of the limestone produced in 1917, was $1,278,908, as compared with $917,559 in 1916, an increase of $361,349 or 39.6 per cent.

The value of the limestone produced in Alabama in 1916 and 1917 classified according to the uses of the stone is given in the following table:

Value of limestone (not including marble) produced in Alabama in 1916 and 1917, according to uses.

USES	1916	1917	Increase or Dec'se	Percent.
Rough building	$13,067	*	——	——
Dressed building	29,597	——	——	——
Riprap	17,969	4,052	$—13,917	— 81.2
Crushed Stone:				
Road making	1,198	14,170	+ 12,972	+ 1083.0
Railroad ballast	.180	——	——	——
Concrete	41,321	54,368	+ 13,047	+ 31.7
Flux	807,344	1,159,035	+351,691	+ 43.6
Agricultural	4,656	8,428	+ 3,772	+ 81.9
Other	2,227	*	——	——

LIMESTONE FOR BUILDING PURPOSES.

The preparation of cut stone for building purposes in Alabama, while on the increase, is not yet what it should be. Practically all of this material comes from the quarries in the Subcarboniferous limestone of the Tennessee Valley, the most important quarries being at Rockwood, in Franklin County, operated by Foster and Creighton Co., of Nashville. This stone is quite similar in appearance, composition, and other qualities to the Indiana stone, and so far as experience in the use of the stone from the two localities in the buildings of the University of Alabama goes, the Alabama stone holds its own under influence of the weather better than does the Indiana stone. Stone steps, door sills, and window sills, buttress caps, etc., of the Alabama stone put in place in 1885 show practically no deterioration in color and wear under foot, and in crumbling and roughening under the influence of the weather, which cannot be said of some portions of the Indiana stone used in buildings erected in 1909-10. The Rockwood quarries have most modern and approved methods of machinery for sawing the stone and handling it in transit to the mills and elsewhere. The stone is of massive formation, of great thickness and extent. Blocks weighing as much as 25 tons, without crack or flaw, are not infrequently quarried, the size of the blocks being practically limited only by the capacity of the hoisting machinery.

The Oolitic variety is most extensively used for building and monumental work. It is of light gray color, uniform grain, and homogeneous texture. It possesses the quality of cheapness, it can be cut to any design required, and it is at the same time strong and durable.

With the installing of adequate machinery at the quarry for doing the finished work, there should never be any longer any reason for going outside of the State for this quality of stone. Already the material has been very extensively used in public buildings in Mississippi, Tennessee, as well as in Alabama. The only reason why it was not used in the recently erected buildings at the University of Alabama was that at the time these building contracts were let, the quarries furnished only the rough sawn stone and there was not in Alabama any establishment adequately equipped for the dressing of the stone in the quantity needed.

The above statements are confirmed by a report on the comparative tests made on the Rockwood stone, and those from Bedford, Ind., and Bowling Green, Ky., by Prof. Robert H. McNeilly, in the Engineering Laboratory of Vanderbilt University.

From this report I give the following extracts:

"GENERAL CHARACTERISTICS.—The Rockwood limestone is an almost pure oolitic limestone with frequent small crystals of calcite distributed throughout its mass. It resembles closely the Bedford stone in appearance, except that it has a slightly more open texture. The Bowling Green stone is finer in grain, softer and more easily pulverized than either the Bedford or Rockwood stones, and contains an appreciable amount of petroleum, which lends somewhat to the ease with which it is worked. In all three stones the texture is exceptionally uniform, as it is almost impossible to detect the bedding planes by eye; however in this respect the Bowling Green stone is most marked, and it is frequently necessary to test by hammer to detect which is the bed plane. Rockwood stone is lighter in color than either the Bedford or Bowling Green stones.

"CHEMICAL ANALYSIS.—The following is an analysis of the Rockwood stone made at my request by Dr. Paul C. Bowers, Chief Chemist of the Tennessee Geological Department:

	Rockwood Stone.
Moisture and loss on heating to 175° C.	0.07
Insoluble siliceous residue (SiO_2, etc.)	0.49
Oxide of Iron and Alumina (Fe_2O_3 & Al_2O_3)	0.30
Carbonate of Lime ($CaCO_3$)	98.23
Carbonate of Magnesia ($MgCO_3$)	0.97
Total	100.06

"PHYSICAL TESTS.—Comparative physical tests of the three samples of stone were made as follows:

Loss in weight on drying,
Cross bending tests,
Compression tests,
Absorption tests,
Per cent. of water absorbed,
Specific gravity in bulk, and of pulverized stone,
Density,
Abrasion tests.

The results of these physical tests are summarized in the CONCLUSIONS below quoted:

"CONCLUSIONS.—The above tests were made as nearly as possible, under identical conditions, and barring the accidental characteristics of the samples, which were selected at random, these results are believed to represent truly the comparative characteristics of each of the stones under consideration.

"The Rockwood stone shows itself to be a superior building stone to others in every respect except density—but even here, since its absorption of water is the lowest of the three, it should prove more durable, while the smaller weight per cubic foot can be placed more cheaply on account of freight charges.

"As compared with the Bowling Green stone, the Rockwood shows a decidedly higher strength, and characteristics which indicate a greater durability. The Bowling Green stone, however, is undoubtedly more easily worked than either of the other two stones, due to its being softer and also to the presence of oil. This oil has the bad effect of staining the stone itself and the contiguous masonry for several years after it is placed, while the very ease with which the stone can be worked makes the Bowling Green very inferior where used for door sills and steps. This is shown well by the Abrasion Test which shows the Rockwood stone in its best light, as a very superior material, for steps, door sills, and other places subject to wear.

"From my examination of these three stones, I believe no builder would make a mistake in using any one of the three, for they are all unquestionably very superior building stones. While each stone may have advantages over the other for some specially desired characteristics, as a building stone for general purposes, each is highly satisfactory.

Respectfully submitted,
ROBERT H. MCNEILLEY,
Assistant Professor of Civil Engineering, Vanderbilt University."

MARBLE.

The marble of Alabama is of two kinds, crystalline, or true marble, and non-crystalline.

The crystalline or statuary marble occurs mainly in a narrow valley along the western border of the metamorphic area, extending from Marble Valley in Coosa County, through Talladega into Calhoun. The length of the marble belt through Coosa and Talladega counties is about 50 miles. The width of the valley carrying the marble as a rule is from one-quarter to one-half mile, widening in places to a mile and a quarter, for example in the neighborhood of Sylacauga.

The quarries longest known are Gantt's and Herd's near Sylacauga, Nix's near Sycamore, Bowie's near Rendalia, and Taylor's and McKenzie's near Taylor's Mill, east of Talladega. From all of these marble was quarried before the civil war.

During 1917 two companies reported production of marble in Alabama, viz., the Alabama Marble Company at Gantt's Quarry and the Moretti-Harrah Company, whose quarry adjoins that of the Alabama Marble Company at Gantt's. The other quarries mentioned are in Talladega County, near Sylacauga.

The plant of the Alabama Marble Company at Gantt's Quarry which was completely destroyed by fire in December, 1910, has been rebuilt and equipped with all the machinery needed for the working up of any kind of finished product.

I think it is fairly safe to say that on the whole the marble from this quarry and immediate vicinity is of the highest grade of commercial white marble now on the market and obtainable in large quantity. There are small quantities of marble produced both in Italy and Vermont that are somewhat freer from coloring matter than the best grades that can be produced in Alabama in any quantity. But on the other hand, the poorest grades in Alabama greatly surpass the poorest grades produced elsewhere, so that the average of the Alabama deposit is probably somewhat higher than that of any other so far developed, not excluding even the marble from the Carrara district in Italy. The marble from this State (Gantt's Quarry) has now a well established reputation and has been used in more than 200 important buildings throughout the United States.

It can be seen in the galleries of the National Museum in Washington.

The Moretti-Harrah Company furnishes the marble in blocks for monumental and rough interior purposes.

A beautiful quality of variegated limestone or marble —red, pink and white—belonging probably to the Cambrian formation, occurs in Shelby County, a mile or two south of Shelby Springs station on the L. & N. railroad, and extending thence southwest for a mile or two. Nothing but prospecting work has been done on this marble. The Trenton limestone in the Appalachian valleys, particularly Jones Valley below Bessemer, contains marble similar to that quarried in the vicinity of Knoxville, Tenn. Also at Pratt's Ferry on the Cahaba River in Bibb County a quarry was for many years worked in this formation and turned out a very beautiful quality of marble varying in color from gray through pink, red and brown shades.

A black marble which is exceedingly promising, has been reported and some development work done near Anniston, and at Piedmont, Calhoun County, and some very handsome specimens of cave onyx have been obtained from near Kymulga in Talladega County.

In the Coastal Plain the St. Stephens limestone of the Tertiary holds ledges of hard, almost crystalline rock capable of taking good polish. The colors vary from nearly white, through shades of yellowish into red, and it would make a handsome decorative marble, especially for inside work.

Other limestone formations, such as the Subcarboniferous and the Knox Dolomite, could in places be drawn upon for marble.

SANDSTONE.

The returns to the U. S. Geological Survey office show a decrease in the total value of the sandstone produced in 1917, of $3,897 or 18.55 per cent, as compared with the 1916 production.

By far the greater part of the sandstone produced in 1917 was ganister.

The following table will show the limestone and sandstone production of Alabama from 1912 to 1917 inclusive:

Value of limestone and sandstone production in Alabama, 1912–1917.

KIND	1912	1913	1914	1915	1916	1917
Limestone	$531,085	$812,664	$787,214	$426,266	$917,559	$1,278,908
Sandstone	27,596	151,111	161,773	80,432	20,995	17,098

SUMMARY.

BECAUSE of the difference in units of measurement employed in the various branches of the mineral industry, a summation of the production of the year can include only the values of the products. It is also to be noted that a simple summation of all the values of the minerals or mineral products listed in this pamphlet would give a value much in excess of the true value, since in many cases, as for instance coal and coke, and iron and pig iron and steel, the second product is directly a product of the first, and the value of the first is included in that of the second. To give the values of both as a part of the total would be to repeat, in a measure, at least a partial value of the first or raw product and would give an erroneous result.

As the Survey has not, however, the figures upon which to base an estimate of the percentage of each product which was used in the manufacture of some other product, the summation of the mineral production of the State as here given will be a simple summation of the values reached by the individual branches of the industry.

According to this rather unsatisfactory manner of summation, which does not include the value of the steel produced, the value of the 1917 raw materials and immediately derived products was $158,127,150, as compared with $94,987,229 in 1916: an increase of $63,139,921 or 66.47 per cent.

The production may be classified as follows:

Raw products	65,423,224
Pig iron	64,309,714
Coke	28,394,212
Total	158,127,150

The more important minerals and products after coal, pig iron and coke, are iron ores, clay products, stone, cement, sand and gravel, and lime given in the order of their relative importance.

Below is a tabular presentation of the value of the mineral products of Alabama, as estimated above for the years 1911, 1912, 1913, 1914, 1915, 1916 and 1917:

Year	Value
1911	$ 52,772,951
1912	60,141,793
1913	67,530,089
1914	56,769,559
1915	61,791,958
1916	94,987,229
1917	158,008,952

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GEOLOGICAL SURVEY OF ALABAMA

EUGENE ALLEN SMITH, *State Geologist*

BULLETIN NO. 22

PETROLEUM POSSIBILITIES OF ALABAMA

PART I
NORTHERN ALABAMA
BY DOUGLAS R. SEMMES
Professor of Geology and Mineralogy
University of Alabama

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PART II
SOUTHERN ALABAMA
BY J. E. BRANTLY

UNIVERSITY, ALABAMA
1920

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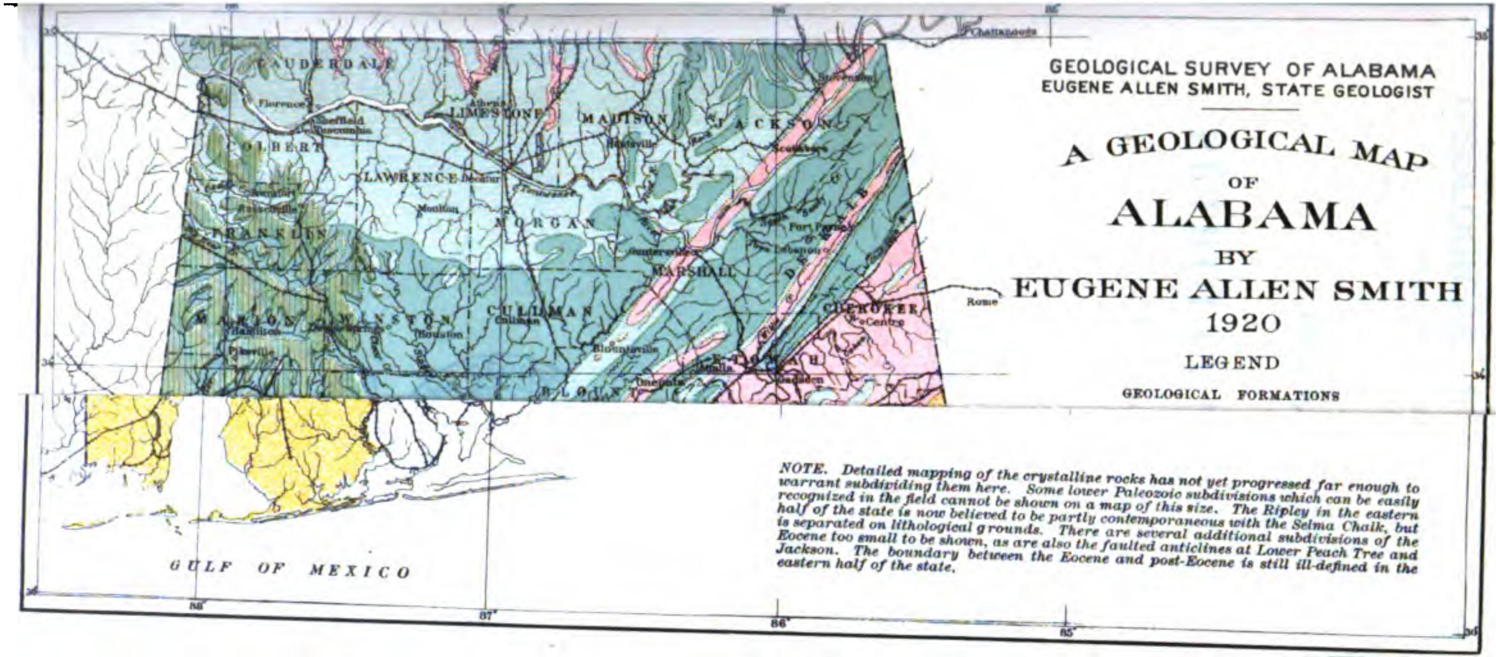

GEOLOGICAL SURVEY OF ALABAMA
EUGENE ALLEN SMITH, STATE GEOLOGIST

A GEOLOGICAL MAP
OF
ALABAMA
BY
EUGENE ALLEN SMITH
1920

LEGEND

GEOLOGICAL FORMATIONS

NOTE. Detailed mapping of the crystalline rocks has not yet progressed far enough to warrant subdividing them here. Some lower Paleozoic subdivisions which can be easily recognized in the field cannot be shown on a map of this size. The Ripley in the eastern half of the state is now believed to be partly contemporaneous with the Selma Chalk, but is separated on lithological grounds. There are several additional subdivisions of the Eocene too small to be shown, as are also the faulted anticlines at Lower Peach Tree and Jackson. The boundary between the Eocene and post-Eocene is still ill-defined in the eastern half of the state.

A. HOEN & CO. BALTIMORE.

GEOLOGICAL SURVEY OF ALABAMA
EUGENE ALLEN SMITH, *State Geologist*

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PETROLEUM POSSIBILITIES OF ALABAMA

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SOUTHERN ALABAMA

BY J. E. BRANTLY

UNIVERSITY, ALABAMA
1920

PRESS
BROWN PRINTING CO.
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ALABAMA

LETTER OF TRANSMITTAL

To His Excellency,
Governor Thomas E. Kilby.

SIR:—I have the honor to submit herewith manuscript of a bulletin on the Petroleum Possibilities of Alabama—Part 1, Northern Alabama, by Douglas R. Semmes, Professor of Geology and Mineralogy, University of Alabama; Part II, Southern Alabama, by J. Edward Brantly, Oil Geologist, Dallas, Texas, with the recommendation that it be printed as Bulletin No. 22 of the Geological Survey of Alabama.

Very respectfully yours,
EUGENE A. SMITH,
State Geologist.

May 1, 1920.

ERRATA.

On page 70, the number 18 in text and below cut should be 17.

On page 78, the number of the cut should be 18 instead of 17.

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INTRODUCTION

By Douglas R. Semmes.

IT IS not surprising that the marked impetus given the prospecting for oil and gas throughout the United States by the recent discoveries in Texas and Louisiana should be reflected to a certain extent in Alabama. During the past year or two the Geological Survey has daily received inquiries as to the possibilities of oil and gas in all parts of the State, and at the present time there seems to be greater activity and interest than ever before. This increasing demand for information regarding the geology of many parts of the State from the point of view of oil and gas production has demonstrated the advisability of presenting in one bulletin all the information that has in the past been scattered through various publications both of this survey and elsewhere, and also the results of field examinations made by the writer in many parts of the State. Owing to the limited time at the disposal of the writer for field work only the more favorable and significant areas could be covered. In other areas the results of previous workers have been summarized and interpreted in the light of present developments. In this way the actual aim of the bulletin, the collecting of all information regarding the oil and gas possibilities in Alabama, is accomplished.

Actual prospecting for oil was first begun in this State in 1865, when the Watson wells were drilled in Lawrence County, though the *Niles National Register*, of August 14, 1841, gives an account of finding oil during dredging operations for the removal of the McGrew shoals on the Tombigbee River. According to this account quite a quantity of the oil was collected, which burned readily on ignition. In 1890, a well was completed in Lawrence County, the production of which was reported at twenty-five barrels per day. After the opening of the Spindletop pool in Texas in 1901, prospecting was carried on much more briskly in this State and a number of test holes were completed in the coastal plain. The discouraging outcome of these tests caused a lull in developments, and it was not until 1916 that the discoveries in Oklahoma and Texas and the increasing price of crude oil spurred on the prospectors to additional efforts in Alabama. Since then there has been a continual increase in development activity and at present time there is no indication of waning interest.

ORIGIN OF OIL.

The question of the origin of oil has been a point of contention among investigators since the first definite theory was advanced some fifty years ago. The controversy grew most intense towards the latter part of the past century, when the majority of investigators became converted to organic theories, leaving the exponents of the earlier inorganic theories considerably in the minority. Since no feasible theory for the converting of organic material into such a homogeneous mixture of hydracarbons as petroleum could be readily suggested the earlier investigators, with little actually reliable data at hand, were rather united in attributing to oil an inorganic origin.

Inorganic Origin.—The most generally accepted of the inorganic theories was that brought forth in 1877 by Mendelieeff, who argued that there probably existed in the interior of the earth large quantities of iron carbide and that the action of downward percolating surface waters on this carbide of iron would produce petroleum. Actual observations in the known oil pools have later conclusively shown that no such reaction could have taken place. However, since certain oil pools are closely associated with igneous rocks, and since as yet no oil just similar to natural petroleum has been produced by the artificial distillation of coal or any such organic substance, certain investigators still remain unconverted to the organic theories. One of the main points of the supporters of the inorganic theory is that petroleum has been found in small globules in igneous rocks. However on microscopic examination this oil proved to be optically inert, while all oils of commercial importance are optically active. These points taken together with the known association of all oil pools with sedimentary rocks and the complete absence of igneous rocks of any kind within great distances of certain important pools has caused the inorganic theories to be virtually discarded. At present practically all assent to the organic origin of oil, though the exact process by which the organic material is converted into petroleum is still unsettled.

Organic Theories.—The supporters of the organic theory are today divided mainly into those who believe that oil and coal alike are derived from land plants, and those who believe marine organisms, chiefly animal, form the main part in the original material of petroleum; but some investigators contend that the material is of both sources.

The earlier superficial observers describing oil in connection with coal and similar substances considered it to be formed from fossil land plants by distillation. Others considered that certain land plants, or land plants in certain localities, have in some cases undergone a special mineralization to liquid and gaseous hydrocarbons rather than to coal. Since that time, however, closer observation has shown that oil is rarely intimately associated with coal and that it is found in sedimentary rocks that from their fossil content show that they were deposited under marine rather than terrestial conditions. Moreover it has been shown that very high temperatures would be necessary to convert vegetable material into petroleum and leave no trace of the original plant structure. In the large deposits of asphalt in Trinidad lignite was found closely associated with the asphalt, and the earlier observers considered them to be of the same origin. Later it was discovered that the asphalt was composed of a mixture of small marine shells, and also pieces of lignite and plant remains were both found in the asphalt itself, showing conclusively that the asphalt could not have been derived from the lignite or the plants as these were found still unchanged.

More recently laboratory experiments have shown that vegetable material could be distilled into petroleum but only at very high temperatures. The petroleum thus formed is of a paraffin base, such as the oils of Pennsylvania. This discovery led to the theory advanced by Peckham that the oils of paraffin base were probably of plant origin, while those of asphaltic base were derived from animal material.

Summarizing the points against the origin of oil from land vegetation:

1. There is usually no connection between coal-bearing and oil-bearing strata. This is well shown in the Appalachian region where the coal-producing measures are barren of oil and vice versa.

2. Where lignite and plant remains are accidentally associated with bitumen deposits they retain their normal character.

3. There is geologic evidence that no such temperature as would be required to distil oil from vegetable material ever existed in the areas of greatest oil accumulation.

4. In certain areas oil is found in limestone and other marine sediments that contain no traces of terrestrial vegetation.

5. Even those oils distilled at high temperatures from coal are quite unlike natural petroleum.

The above points indicate that it is improbable that oil is derived from the distillation of land plants, except the possibility of such distillation in areas where igneous material has been intruded into sedimentary rocks rich in vegetable material of such nature.

This, therefore, restricts the origin of oil to animal material—chiefly marine, since the land animals would obviously be only rarely and accidentally preserved—and vegetable material of marine origin such as the marine algae.

This dual origin of petroleum is now accepted by the large majority of investigators, and it only remains to determine the nature of the processes that brought about the change from the original marine animal and vegetable material to the oil. Everyone who has closely examined any extensive region of sedimentary rocks is impressed with the abundance of marine shells and other indications of prevalent marine animal life at the time of deposition. It is rare that land animals are thus preserved, but occasionally beds composed almost wholly of the bones of land animals have been found, and in one instance (Ventura County, California) these remains are directly associated with an asphalt deposit. The marine vegetation is rarely preserved in recognizable form, so that we are unlikely to appreciate the importance of this source of organic material unless we consider its abundance in the present sea.

These marine organisms, especially the animals, sink to the bottom on dying and there accumulate in an environment almost wholly free from oxygen. Under these conditions a slow decomposition is set up, chiefly through the agency of certain denitrifying bacteria. In this way the nitrogenous tissues of the organism are decomposed and eliminated soon after death leaving only the fatty parts and oils. These fats are comparatively stable but by slow decomposition through long ages of time at rather low temperatures they are changed over into natural petroleum. This theory, termed the Engler-Hofer theory, has been fully outlined by Dalton* and has now been generally accepted as agreeing with known facts and on the whole having the greatest degree of probability.

According to this theory then it is the marine organic material that has played the principal role in the origin of oil, and it is quite possible that the paraffin-base oils are derived from marine vegetable material, chiefly marine algae, while the asphaltic-base oils may be derived from marine animal organisms.

It should be kept in mind that no distinction is made between land and marine animals in themselves, but the distinction is made in the nature of the environment of the two after death. It is quite plain to all that animals dying on the land where oxidizing influences are active would be rapidly and completely decomposed and all the volatile parts carried off into the atmosphere. Therefore it is only in the sea where non-oxidizing conditions prevail that petroleum will be formed, and accordingly it is only in the marine sediments, the black and brown shales and dark impure limestones that deposits of oil may be expected. According to Schuchert,** "All rock formations accumulated directly beneath the atmosphere, as the pure continental deposits, must therefore be devoid of commercial quantities of petroleum. Then, too, all deposits either of the fresh waters or of the seas, which are periodically subjected to atmospheric weathering during their time of accumulation, are also lacking in oil in paying quantities. Hence, we may further conclude that all red or reddish, yellowish, or white, rain-pitted or sun-cracked deposits, either of continental, fresh-water or semi-marine origin, are lacking in petroleum in large amounts."

Therefore the nature of the sediments deposited and the conditions of their deposition are of utmost importance in determining the possibilities of a new area. In Alabama, considering the formations of the northern part of the State, the Coal Measures are of dubious value, though its extensive shale series developed in certain localities is probably in great part of marine origin and of value in the generation of petroleum. The limestones of the Subcarboniferous are typically of marine origin and throughout them oil is found disseminated. Likewise the limestones of the middle and lower Paleozoic, (the Niagara, Trenton and Knox) are of marine origin, and though in part widely dolomitized, still they show oil dissemination in places.

---

* Leonard V. Dalton: On the Origin of Petroleum, Econ. Geol., Vol. 4, pp 603-631 (1909).

** Charles Schuchert: Petroliferous Provinces, Discussion, Mining and Metallurgy, No. 155, pp. 3058-3070, Nov. 1919.

The formation of the central and southern parts of the State can be considered likewise. Beginning with the Tuscaloosa formation of Cretaceous age, it is found to be of continental or fresh-water origin and therefore no oil should be expected in it. The succeeding Cretaceous formations show more and more the characteristics of marine sediments as one goes toward the coast, until we reach the Selma Chalk, which is undoubtedly marine. Beyond this the Eocene formations show locally both marine and near-shore or brackish water characteristics and are of dubious value. It should be remembered, however, that in the southern part of the State drilling started in the Eocene formations would probably be continued to the depth of the Tuscaloosa series which at this point, being farther removed from the Cretaceous shore-line, might possibly be a marine series and a potential oil producer. So it is readily seen that the examination and appreciation of the character of the sediments most favorable for oil production is of great significance in attempting to predetermine the area of the greatest possibility in Alabama.

MIGRATION OF OIL.

From the above brief outline of the present accepted theory it is evident that the mother-rocks of petroleum are the dark petroliferous shales of marine origin and similar impure limestones, yet all shales are not oil shales. Schuchert* estimates that only from ten to fifteen per cent of the shale formations are decidedly petroliferous, the greater majority being, as he expresses it, mere mudstones deposited in fresh or brackish waters, or as lake or river deposits, or as marine deposits under conditions of sparsely developed life, or under conditions where the preservation of the fatty portions of the existing organisms would be improbable. So we see that it is only occasionally that the conditions are favorable for the preservation of the fatty portions of the organisms in the marine sediments and the development of typical petroliferous shales.

---

* Op. Cit., p. 3064.

Granted that the shales are the mother-rocks of oil we must next explain the fact that large accumulations of oil are rarely found in shales, but rather in sandstones and other sedimentary rocks of considerable pore space. That is, the oil formed in shales and similar formations, has in some past time, in large part left the shales and migrated into other sedimentary formations.

The rapidity and facility with which this migration takes place and the kind of formation selected as a reservoir by the oil will depend upon a number of factors, some of which are of much significance in the accumulation of oil in commercial quantities.

Hydrostatic Pressure.—Beneath the surface in all parts of the earth there is a zone in which the rocks are saturated with water. Its depth varies with the amount of rainfall and the nature of the topography. The weight of the water causes it to extend downward as far as any fissures or pore-spaces remain in the rocks. The surface tension of water is about three times as great as that of oil, and therefore capillary attraction is thrice as effective in drawing water into the more minute cavities of capillary size as it is for oil.* If oil was originally formed in fine-grained shales occurring disseminated in minute globules the effect of hydrostatic pressure in conjunction with capillary forces would be to force the oil out of the shales and into formations containing larger pore-spaces. In Southern Alabama, the formations, gently inclined with the slope of the country to the south, are saturated with water under considerable head and in places water will rise in wells to the surface and make an artesian flow. This is because the formations obtain part of their water content from their outcrops farther to the north and at greater elevations. Therefore, in the coastal plain of Alabama we may expect good hydrostatic pressure and the oil, if there is any, will migrate and accumulate more freely.

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* The Capillary Concentration of Gas and Oil, by C. W. Washburne, Trans. Am. Inst. Min. Engrs., Vol. 50, pp. 829-842, 1914.

Character of the Formation.—It is obvious that oil will migrate more freely in a porous sandstone or limestone than in a fine-grained shale or clay. Moreover certain sandstones are much more porous than others and offer better channels for the migration of oil and reservoirs for its storage. In this connection the microscopic examination of the sediments in question is often of much importance in attempting to predetermine their effect upon the migration of oil contained within them.

Dip of the Strata.—Since oil is lighter than water it will rise, and the general tendency of its migration will be toward the surface. In this way a vast amount of oil formed during past geological time has migrated to the surface and been lost. The oil now accidentally entrapped to form the known pools probably constitutes less than one per cent of all the oil originally formed in the sedimentary rocks. Since oil migrates more rapidly in porous formations it will obviously move even faster and more completely toward the surface if the formation is vertical. So the angle of inclination or the dip of the strata must be considered a rather influential factor in oil migration.

Nature of the Oil.—The specific gravity of oil will affect at least the rate of migration even though it may not alter the final result. Certain crude oils, such as some of the Mexican oils, are so viscous that they must be heated before they will flow at all, while others are so light that they are much more fluid than water.

Extent of the Migration.—The fact that oil is found in isolated and unrelated pools is sufficient evidence of the fact that it has migrated from its original disseminated condition in petroliferous shales to points that favor its entrapment and accumulation. That a certain amount of migration has taken place is conceded by all investigators, but at present there is a tendency by some to question the previously accepted ideas regarding the extent and mechanics of this migration. The actual extent of migration is of vital importance in certain regions where the prospective series does not contain any large amount of bituminous matter, and where oil accumulation, if any exists, must have been brought about by comparatively long-distance migration. The geologist, therefore, too often concludes that given the favorable conditions of structure and storage, oil will accumulate even from a series poor in bituminous matter by extensive migration and concentration of the petroleum content at some favorable point. A careful appraisal of the conditions in a large variety of oil fields leads the investigator to the conclusion that the factors determining the extent and efficiency of migration are exceedingly complex, and with our present lack of knowledge regarding many of the contributory factors it is impossible for one to come to any definite conclusion, nor would it be possible to lay down any set of principles that would hold good for any number of fields.

Recently certain very suggestive experiments have been performed by Alex W. McCoy* that throw additional light upon both the origin and migration of oil. Mr. McCoy subjected oil shale to intense pressure by compressing it in a tube, the central portion of which was thinner to allow bulging; thereby inducing flowage in the shale, and without causing an appreciable amount of heat, developed small globules of oil. The material used was typical oil shale capable of yielding about 25 gallons to the ton, but no oil could be removed by solvents prior to the experiments. Mr. McCoy concludes from these experiments that solid bituminous material in the mother formations is only changed to petroleum by pressure in the local areas of folding, that is, the pressure accompanying the actual folding which might give rise to the anticline in which the oil is later entrapped, originally caused the formation of the oil from the bituminous mother rock. Moreover, he concludes that the entire amount of oil in any field could readily be derived from the bituminous shale in close proximity to the producing horizon; and that extensive migration does not occur, because away from the area of movement and associated pressure the oil would not be formed, and also the bituminous shales immediately adjacent to the point of accumulation are amply sufficient to produce the oil in the existing pool. This, however, presupposes a comparatively highly bituminous shale series immediately associated with the oil bearing horizon, which is not always the case. Moreover, in Wyoming where there do occur extensive shale series there is almost conclusive evidence of long distance migration, for there we find the pay sand drained of its oil content for many square miles, the oil having migrated along the axis of elongated anticlines for sometimes 10 or 15 miles to the highest point of the structure.

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* Notes on Principles of Oil Accumulation, Jour. Geol., Vol. 27, pp. 252-262, 1919.

In the coastal plain of Alabama there is no such highly bituminous shale series, so that the potential oil content per cubic foot would hardly compare with that of the prolific Mowry shales of Wyoming. There will not be, therefore, sufficient oil derived from the immediately adjacent mother rocks to fill or partly fill the known structures. So if we preclude the possibility of comparatively long-distance migration we greatly lessen the possibility of the occurrence of oil in commercial quantities in this region.

OIL RESERVOIRS.

Those sedimentary formations containing the largest amounts of pore space are naturally the best adapted for oil reservoirs.

Sandstones.—Of those sediments usually found in a marine series the sandstones are the commonest reservoir-rocks for oil. The porosity in the average sandstone varies from 5 to 25 per cent. The normal oil sands average around 10 to 15 per cent. It occasionally happens that sandstones which are normally quite porous are locally cemented and indurated by circulating siliceous waters and their value as oil reservoirs much impaired. The percentage of porosity can readily be determined by physical tests or by microscopic examination.

Limestones.—The porosity in limestones varies from 0.5 to 13 per cent. Some limestones contain sandy layers where the pore space may run as high as 15 per cent. This is true of the Tuscumbia and Trenton limestones of the northern part of the State. Such horizons would consequently form good oil reservoirs.

Dolomites.—By certain processes not clearly understood by geologists limestone is sometimes changed from the pure calcium carbonate to a mixture of calcium and magnesium carbonates. This change is attended by a certain amount of shrinkage and resultant cavity formation. Therefore in certain dolomites the amount of cavity and pore space runs rather high. This is the case with the Knox dolomite; but for other causes that will be discussed later the Knox is not considered a favorable horizon for oil.

Cavities.—Even though enormous quantities of oil may be derived from one well yet it rarely happens that there are actually cavities in which the oil is stored. It is possible, however, that cavities formed in limestones by the solvent action of underground water may subsequently become filled with petroleum and play an important role in the origin of small pools.

THE ACCUMULATION OF OIL.

We have seen that oil migrates freely along porous, inclined strata and that the general tendency is upward rather than downward. So if we consider the strata folded in the form of an arch, the oil should rise to the crest of the arch and there remain entrapped (Fig. 1), if there is an impervious stratum above, and since we have to deal with three dimensions the oil would migrate along the pitch of the arch (unless it were horizontal) until it reached the highest point. A fold, therefore, in which the strata dipped away in every direction from a central point would be the ideal trap for oil. Such a structure is termed a dome or quaquaversal structure.

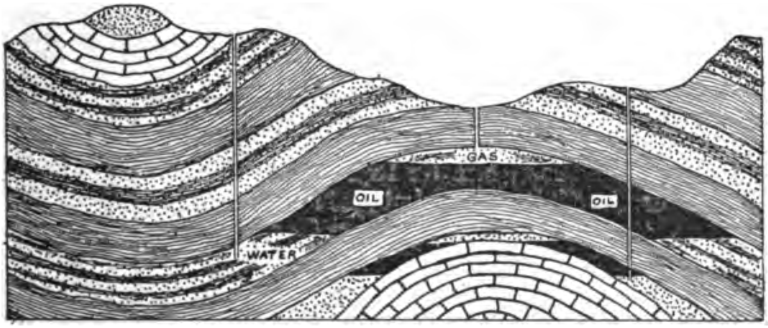

FIG. 1. Cross-section showing the idealized occurrence of oil, water and gas in an anticline. The lower oil-producing sand shows local thinning near the axis of the fold thereby decreasing the size of the reservoir and the amount of production from this sand.

Anticlinal Theory.—This connection between structural arches or anticlines and oil pools was recognized as early as 1861 by T. Sterry Hunt, but it was not until 1892 that the idea was fully developed and put to practical test by I. C. White.* In certain areas, however, it was soon discovered

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* Geol. Soc. Amer., Bull. 3:187, 1982.

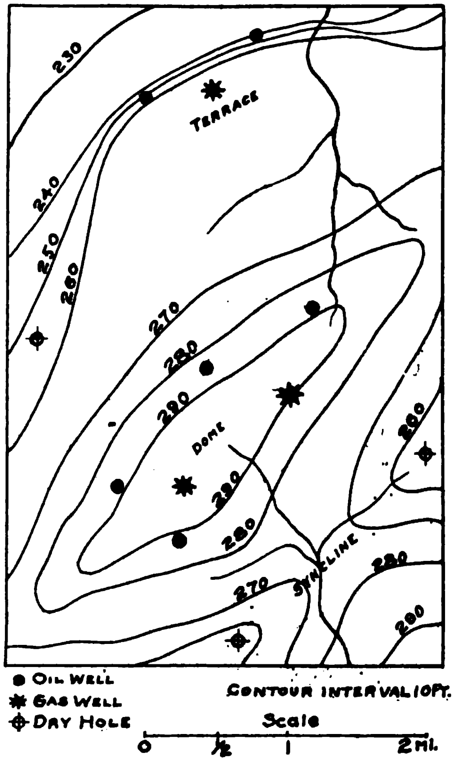

FIG. 2. Structural contour map showing a dome and terrace expressed by contours projected on the producing horizon. Terraces of this nature are often productive in Texas.

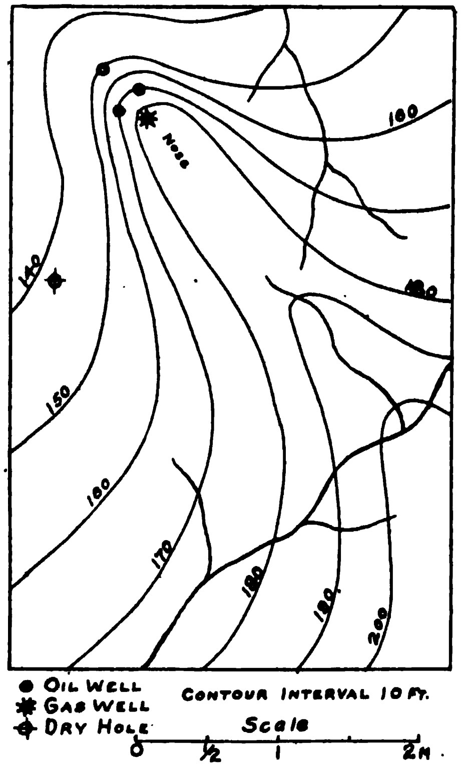

FIG. 3. Structural contour map showing a plunging anticline or nose with the production associated with a change in the pitch of the axis.

that the synclines or structural troughs produced more oil than the anticlines. This was readily explained by the fact that in these areas the porous stratum in which the oil moved was practically devoid of water and without hydrostatic pressure the oil sank to the lowest points, the synclines, instead of accumulating along the axes of the anticlines.

Domes.—Since the development of the anticlinal theory it has been recognized that oil and gas will accumulate in numerous kinds of structural traps other than anticlines and synclines. As has been stated, the ideal trap for oil is the dome, especially in areas of strong hydrostatic pressure such as Wyoming. In the accompanying illustration (Fig. 2) a dome is depicted by contours projected upon the surface of the oil-bearing sand.

Noses and Terraces.—Oil migrating up an inclined stratum may possibly come to rest where the dip lessens abruptly and the strata become approximately horizontal. Such a structure is termed a terrace; in Oklahoma and Texas such terraces are often underlain by moderate-sized pools. At other points the strike or direction of outcrop may change abruptly and give rise to such a structure as is shown in Figure 3. This is termed a nose, and is also frequently associated with production in the Mid-Continental fields.

Sand Lenses on Monoclinal Slopes.—The particular geological conditions that brought about the deposition of a sandstone might have been essentially local so that the sandstone would not extend over a great area, but occur over only a limited area in the shape of a lens. If elsewhere shale deposition were going on this sandstone lens would be completely surrounded and imbedded in a shale series. The

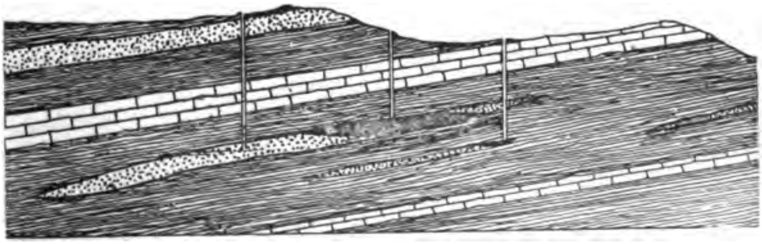

FIG. 4. The occurrence of oil in a lenticular sand, interstratified in a gently dipping sedimentary series, the principle of accumulation being the same as in an anticline.

effect of hydrostatic pressure would be, therefore, to force the oil and gas from the shale into the sandstone and there it would be separated into layers of gas, oil and salt water, as illustrated in Figure 4, by gravity.

Salt Domes.—In Louisiana and Texas there occur large masses of salt in the Tertiary and Cretaceous formations of the coastal plain, which are usually expressed on the surface as slight topographic elevations. These elevations have been explained by the force of the crystal growth of the salt beneath resulting in the gradual arching up of the overlying formations (Fig. 5). In this way a dome is made and in some cases oil accumulation is associated with these structures, as is the case with the salt domes at Spindletop, Humble, Goose Creek and West Columbia, Texas. In Alabama we have formations of similar character and geologic age, but up to the present time no salt domes have been discovered.

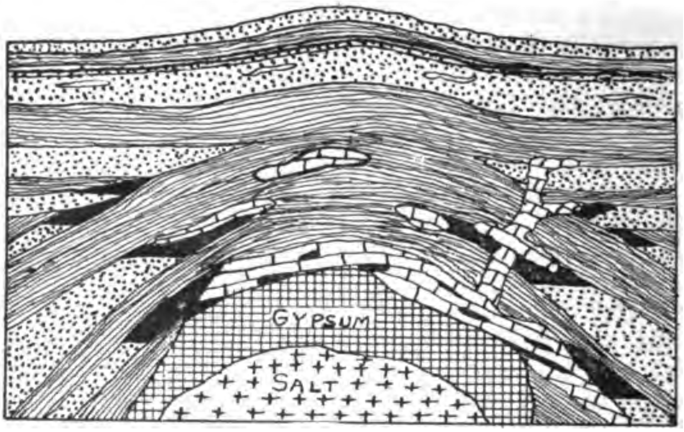

FIG. 5. Generalized section of a salt dome (after Fenneman) showing the irregular distribution of the oil associated with such structures and the lengthy period of dome growth as indicated by the unconformities in the overlying sediments.

Volcanic Plugs.—In Mexico volcanic rocks have intruded and arched up the surrounding sediments, and in some cases very large accumulations of oil have developed (Fig. 6). Such instances would be the only ones in which sufficient heat would develop to possibly cause the distillation of oil from land vegetation.

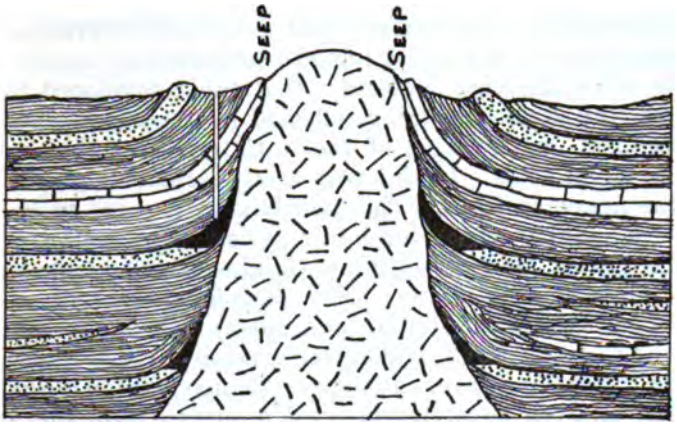

FIG. 6. Generalized section of a petroliferous series intruded by a volcanic neck or a dike, and the subsequent accumulation of oil in the upturned strata. Much of the oil of Mexico has accumulated under structural conditions of this nature.

Faults.—Petroliferous formations may sometimes be broken by dynamic processes and the reservoir rock effectually sealed by being brought into juxtaposition with impervious shales as is shown in Figure 7. In some of the Asiatic fields this type of trap is occasionally encountered.

Unconformities.—It sometimes happens that a petroliferous series is deposited, consolidated, then uplifted and folded, and later subjected to erosion, and on top of this folded and eroded series is deposited another series which may or may not be petroliferous. In such a case the overlying series is said to be unconformable with respect to the underlying. It is obvious that in such a case the structure

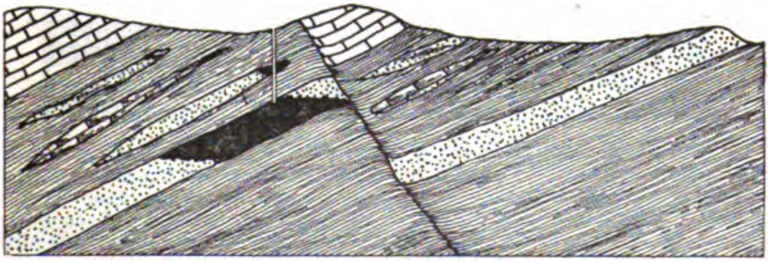

FIG. 7. Oil accumulation associated with a faulted petroliferous series in which the oil sand has been effectually sealed by being brought into juxtaposition with an impervious shale series.

as expressed on the surface will not wholly correspond to the structure of the series lying unconformably below. It is quite often the case, however, that folds developed in the underlying series are later reflected in the upper series by subsequent continuation of the initial stresses that caused the original folds. In this way a comparatively gentle fold in the upper series may be underlain by a much more pronounced fold in the older lower series. The conditions in the Healdton field of southern Oklahoma are somewhat of this character (Fig. 8). The petroleum content of the lower series (Mississippian and older) has apparently migrated in great part to the buried erosion surface separating those formations from the upper (Pennsylvanian-Permian) series, or even beyond this erosion surface into the sands of the Pennsylvanian. Production, therefore, does not always occur in direct relation to the surface structure, and some of the most prolific horizons are closely associated with the erosional surface separating the two series. Somewhat similar conditions occur in the Ranger field of Texas, where relatively unimportant noses and terraces (Fig. 3), are represented in depth by pronounced structures, of the same variety, and the greater part of the production comes from the upper limestones of an underlying unconformable series.

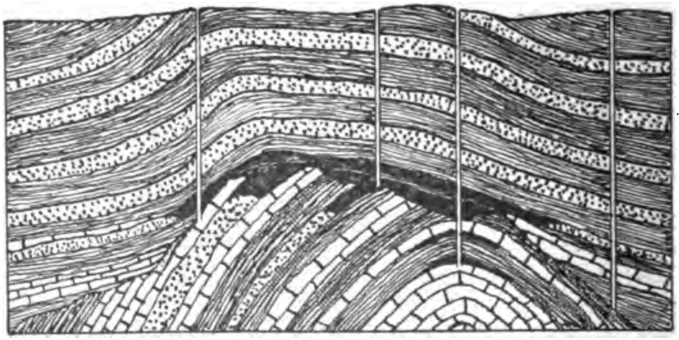

FIG. 8. Generalized cross-section of the Healdton field of southern Oklahoma (after Powers) showing the relation of unconformities to oil accumulation. The older fold is usually represented in the younger series by a less intensive deformation, but the subsequently developed structures as determined at the surface may be quite dissimilar to those developed below the unconformity.

THE RELATION OF PRODUCTION TO STRUCTURE.

The accumulation of oil in unfavorable structures of the kind described above is obviously restricted to those regions where the structures occur in close association with petroleum-bearing series. It is apparent, moreover, that if the petroliferous series is prolific the favorable structures will be more frequently and more completely filled. The recent emphasis by many writers of the local geological conditions of sedimentation necessary for the development of a petroliferous series has led some investigators to the conclusion that the conditions of sedimentation may be more influential as a factor in determining oil accumulation than the distribution and character of the structures developed in the particular region. W. F. Jones in a recent paper* has attempted to show that the distribution of the oil pools in Pennsylvania and Oklahoma is more directly related to initial conditions of sedimentation than to the subsequent distribution of structure, and that the accepted favorable structures may be relatively unimportant in determining the accumulation of petroleum as compared with the original basins of accumulation. Certain of Mr. Jones' conclusions are:

1. "No wide lateral movement of oil has taken place and the present position and shape of oil pools closely conforms to the underlying or overlying source of supply."
2. "The areas of supply are lagoonal areas close to and generally parallel with the coast line at the time of deposition."
3. "Pools generally occur in alignment corresponding to the coastal lagoonal areas, each line of pools corresponding to successive shore lines, with generally barren belts intervening."
4. "Larger pools are elongated to correspond to the prevailing elongation of the larger basins of accumulation."
5. "Certain types of structure are favorable for large initial yield of oil, since domes, if they happen to exist in a productive area, act as pressure traps for gas."
6. "Oil pools, in Pennsylvania and Oklahoma, may be largely of predeformational accumulation.
7. "A study of the paleography and a delineation of

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* The Relation of Oil Pools to Ancient Shore Lines, by Wm. F. Jones, Econ. Geo., Vol. 15, pp. 81-87, 1920.

ancient shore lines would prove of considerable value in directing the major drilling developments."

8. "There may be extensive areas of favorable oil land in regions condemned at present because of the lack of so-called favorable structure."

While it is undoubtedly true that the delineation of the present pool is greatly influenced by the location of the source of supply, yet it must be kept in mind that the vast majority of the oil pools of Oklahoma (as a type region) are directly related to structures that have been recognized as favorable for oil accumulation. Hager concludes,* from the tabulation of all the principal pools of Oklahoma and some in Kansas that:

1. "Of the 75 pools listed, which comprise the principal pools of Oklahoma and a few in Kansas, all but four are on well-defined structure."

2. "It will be seen that by far the greater proportion of the representative fields listed are of the dome or anticlinal type. Terraces come next in order, while lenses form a small minority. Of the list 45 pools, or 60 per cent., are on domes and anticlines; 15 pools, or 20 per cent., are on terraces, and 11 pools, or 14.7 per cent., are undivided, while 4 pools, or 5.3 per cent., are on lenses. If those fields on undivided terraces and domes (14.7 per cent.) are split equally, which is fair enough, then 7.35 per cent. will be added to the dome, and to the terrace list; so that 67.35 per cent. are on domes and anticlines, 27.35 per cent. are on terraces, and 5.3 per cent. on lenses, which is a fair ratio for the Mid-Continent fields."

3. "Also, it is interesting to note that of 45 pools found in 1913 and later, 30 pools, or 66 2/3 per cent., have been opened by the geologists—a truly remarkable record. Of these the geologists have credit for but one terrace."

More recent work by K. C. Heald shows that over 88 per cent. of the anticlines and domes of the Osage Nation are oil bearing as compared with about 15 per cent. of the synclines. The impartial observer, therefore, is forced to the conclusion that even though the distribution of the petroliferous formations comprising the source of the oil necessarily determines the larger outlines of the oil-producing areas, yet the local accumulations in the known pools have been so conclusively demonstrated to be related to and dependent upon structure, that one inevitably concludes that the factor of structure still remains the most important in the forecasting of petroleum-producing areas.

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* Evidence of the Oklahoma Oil Fields on the Anticlinal Theory, by Dorsey Hager, Trans. Am. Inst. Min. Engrs., Vol. 56, pp. 843-846, 1916.

THE GEOLOGICAL DISTRIBUTION OF OIL.

Commercial production was first found in this country in the Carboniferous strata of Pennsylvania, and subsequently large production has been obtained from several younger formations. Some time ago it was the popular idea that oil would not be found in sediments older than the Carboniferous. At that time there was thought to be an intimate connection between oil and coal formation, and since no coal is found below the Carboniferous it was reasoned that oil would likewise be restricted to that and younger formations. This idea caused many operators to hesitate in developing areas underlain by formations older than the Carboniferous. We have seen, however, that there is no connection in origin between oil and coal and that the conditions which we now consider essential for oil formation and accumulation did exist during several of the geologic periods prior to the Carboniferous. These points have now been proven by the discovery of oil in large quantities in the Trenton (Ordovician) formation and in lesser quantities in the Devonian and Silurian strata. We may expect the formation of oil, therefore, in formations of any geological age, when the conditions are ripe for the preservation, in an environment free from oxygen, of abundant marine organisms. In this country the most prolific horizons are the Carboniferous, Cretaceous and Miocene, with lesser production from the Ordovician, Silurian, Devonian, Eocene, Oligocene and Pliocene. Up to the present time no commercial quantities of oil have been found in the Cambrian or older formations, and even though there is widespread evidence of abundant marine life in the seas of these early periods it is hardly probable that important accumulations will be found in these sediments, for they have been subjected almost universally to much disturbance and deformation and in addition have lost much of their oil content by evaporation during the enormous periods of time that have elapsed since their deposition.

THE GEOGRAPHICAL DISTRIBUTION OF OIL.

The geographical distribution of oil is a subject now attracting much of the attention of petroleum geologists and operators. Since the development of recent ideas regarding the origin of oil and the geological conditions necessary at the time of sedimentation, geologists are beginning to acquire more comprehensive ideas as to the areas of the earth's surface where oil will be most likely found, and other areas where the conditions are impossible for its formation and accumulation.

In a recent paper Woodruff* has outlined some of the factors that will control the geographical distribution of oil. Those areas in which the formation and accumulation is possible he has termed *petroliferous provinces,* and in North America he has outlined such provinces as follows:

1. In Western Alaska. Oil seeps are known in this province; there has been some drilling but as yet no considerable production.
2. In Western Canada from the Arctic Ocean to and including Montana. Some commercial production may be found in the northern part of this province; the southern part is of doubtful value.
3. Along the Pacific Coast in California, Oregon, and Washington. Only the southern part of this province seems important.
4. In Wyoming, Colorado, and a part of New Mexico. Only small areas in this province will be productive.
5. In Oklahoma, Texas, and Louisiana. Considerable areas in this province are productive and others will probably be found.
6. From Pennsylvania to and including Illinois and extending southward into northern Alabama and Mississippi.
7. In Lower California. This province seems of doubtful value but may be productive.
8. On the eastern coast of Mexico.

Commenting upon the delineation of the petroliferous provinces by Woodruff, Shuchert** has suggested that the petroliferous and non-petroliferous rocks of any continent be determined by the application of the following principles:

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* E. G. Woodruff: Petroliferous Provinces, Mining and Metallurgy, No. 150, pp. 907-912, June, 1919.

** Op. Cit., p. 3059.

1. The impossible areas for petroliferous rocks.

(a) The more extensive areas of igneous rocks and especially those of the ancient shields; exception, the smaller dikes.

(b) All pre-Cambrian strata.

(c) All decidedly folded mountainous tracts older than the Cretaceous; exceptions, domed and block-faulted mountains.

(d) All regionally metamorphosed strata.

(e) Practically all continental or fresh-water deposits; relic seas, so long as they are partly salty, and saline lakes are excluded from this classification.

(f) Practically all marine formations that are thick and uniform in rock character and that are devoid of interbedded dark shales, thin-bedded dark impure limestones, dark marls, or thin-bedded limy and fossiliferous sandstones.

(g) Practically all oceanic abyssal deposits; these, however, are rarely present on the continents.

2. Possible petroliferous areas.

(a) Highly folded marine and brackish water strata younger than the Jurassic, but more especially those of Cenozoic time.

(b) Cambrian and Ordovician unfolded strata.

(c) Lake deposits formed under arid climates that cause the waters to become saline; it appears that only in salty waters, (not over 4 per cent.?) are the bituminous materials made and preserved in the form of kerogen, the source of petroleum; some of the Green River (Eocene) continental deposits (the oil shales of Utah and Colorado) may be of saline lakes.

3. Petroliferous areas.

(a) All marine and brackish water strata younger than the Ordovician and but slightly warped, faulted, or folded; here are included also the marine and brackish deposits of relic seas like the Caspian, formed during the later Cenozoic. The most certain oil-bearing strata are the porous, thin-bedded sandstones, limestones, and dolomites that are interbedded with black, brown, blue, or green shales. Coal-bearing strata of fresh-water origin are excluded. Series of strata with disconformities may also be petroliferous, because beneath former erosional surfaces the top strata have induced porosity and therefore are possible reservoir rocks.

(b) All marine strata that are, roughly, within 100 miles of former lands; here are more apt to occur the alternating series of thin and thick-bedded sandstones and limestones interbedded with shale zones.

FACTORS DETERMINING THE GEOGRAPHICAL DISTRIBUTION.

The Character of the Sediments.—It is apparent, therefore, that the prime factor determining the geographical distribution of petroliferous areas is the lithologic character of the rocks involved. Only the sedimentary areas need be considered, and of the sediments those formed under subaerial conditions of land deposition can be eliminated as well as those rarely encountered marine sediments formed in the deeper portions of the ocean. It is between these two regions in the areas adjacent to the ancient shore lines, existent at the time of deposition, that the geologist should devote his closest attention. The importance of these former shore lines has been for some time recognized by geologists but no concerted action has been taken in regard to outlining and mapping in detail these areas of greatest significance.

The Nature of the Reservoir.—We have seen that only a minute fraction of the areas termed petroliferous provinces actually produce oil in commercial quantities. This is chiefly due to the lack of adequate structural traps to prevent the oil migrating to the surface and there being lost. Still in petroliferous areas there are many well-defined and favorable structures that are non-productive. The causes for such non-productivity have in some cases never been discovered. Local changes in the original conditions of sedimentation; leakage points in the structure in depth, not expressed upon the surface; age of the folding that gave rise to the structure as compared with the age of the sediments themselves; all such causes may separately or in conjunction prevent accumulation even when other factors are favorable.

In addition there is the question of local efficiency of the reservoir in bringing about the accumulation. We have seen that sandstones are among the most porous of rocks and make the best reservoirs. If, however, the sandstone has been secondarily cemented by the action of circulating siliceous waters in the area where favorable structure has been formed, resulting in the reduction of pore-space to the minimum, the value of the rock as a reservoir will be much diminished and no large accumulation will take place. Or, if at the time of sedimentation the conditions that brought about the deposition of a coarse-grained sandstone were changed and mud as well as sand were locally deposited, in this locality the resultant sediment would be a shaly sandstone of very little pore-space and of little value as a reservoir. Local thinning in the sandstone or the development of "partings," local wedges of shales and other non-porous sediments, may also detract from the value of the reservoir.

Metamorphism.—The effect of metamorphism on the distribution of oil had not been fully appreciated until David White formulated the carbon ratio theory. The substance of this theory will be given more fully under a subsequent heading. In main, however, it postulates that in areas where deformation and resultant metamorphism have occurred to such an extent that the fixed carbon in the coals of the same area runs as high as seventy per cent., calculated upon a pure coal basis, it is extremely improbable that any important accumulation of oil will be found. This criterion is obviously only applicable to those sedimentary areas where both carbonaceous and petroliferous sediments occur.

Climate.—If one studies the distribution of the important oil fields of the earth's surface he will be impressed with the fact that they seem to be restricted to certain ranges in climate. Mehl* has recently shown that all the more important oil fields lie between 20° and 50° north latitude, and in regions where the present mean annual temperature varies between 40° and 70° F. If subsequent discoveries conform to the same rule there would be suggested some possible relation between oil distribution and climate. The writer, however, can at present see no connection between actual climates and oil distribution, and believes that this apparent zonal arrangement is largely due to accident. The climates of the past, on the other hand, have been shown to be of prime importance in the development of abundant life and would consequently be among the determining factors in the distribution of the petroliferous areas.

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* M. G. Mehl: Some Factors in the Geographical Distribution of Petroleum, Bull. Sci. Lab., Denison Univ., Vol. 19, pp. 55-63, 1919.

THE FIELD WORK OF THE GEOLOGIST.

The geologist in making field examinations must have several points in view. In the first place he must determine by the evidence of the fossils or by any other means he may have the relative position of the sediments, with which he has to deal, in the geological column. In many cases the age of the formation has been determined by previous workers, but in wholly undeveloped regions it often happens that the geologist must rely wholly upon his own investigations to obtain all data necessary to enable him to draw correct conclusions. In such cases he must first determine the age of the formations, then make a careful study of the nature and origin of the sediments in which he hopes to find oil. This can only be done at points where the strata in question are exposed, and the exposures may be separated from the areas of favorable structure by considerable distances, so there enters the question of correlation between the points of exposure and the site chosen for a test. In examining the formations involved, or what is termed the local geologic section, the geologist must measure carefully each distinct formation and make careful note of its lithologic character in order to determine its possibilities as a petroliferous series; he must seek, measure and examine minutely all formations that could be considered as possible reservoirs; he must locate these with respect to the other formations of the section; and to the best of his ability forecast their depth at the point he has chosen for his first test well. For example, consider a test being made in Monroe County in the southern part of the State. In this area the objective or possible pay horizon might be the Tuscaloosa formation, unexposed except almost a hundred miles to the north. The geologist must therefore, consider this formation where exposed and from this examination, aided by his general fund of geological knowledge draw his conclusions as to its depth and character in Monroe County. Its depth he can determine from the average dip of the other strata exposed in the intervening area; its character he has determined at the point of outcrop to be decidedly unfavorable for an oil-producing series. However, he knows that the Cretaceous shore line roughly approximated the southern boundary of the Tuscaloosa formation as exposed at present and as one continued southward in this Cretaceous sea conditions should become more and more similar to those necessary for oil formation. Therefore, he infers that the Tuscaloosa formation as developed a half mile below the surface in Monroe County might readily be a marine formation with all the requirements of a petroliferous series. Naturally he cannot prove these surmises without making a test, and he may recommend that a test be made for he logically reasons that the series presents good chances, while if he had known nothing of the local geological conditions in Cretaceous times, he may have inferred that the Tuscaloosa formation retained its same character to the south and so would be worthless as a producing horizon (Fig. 9).

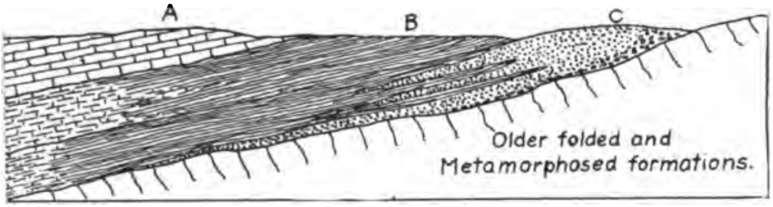

FIG. 9. Generalized section of the coastal-plain of Alabama showing (C) the Tuscaloosa formation, a typical continental formation, grading into a marine series in the direction of the early Cretaceous sea, and (B) the Eutaw shales and sands grading into marine shales and shaly limestones, and finally (A) the Selma Chalk, a marine formation representing a period of comparatively deep and clear water conditions of deposition in later Cretaceous time. This is a hypothetical set of conditions, which if true would greatly increase the possibilities of oil production from the Tuscaloosa and Eutaw formations in southern Alabama.

In addition to the interpretation and correlation of the section the geologist must seek localities where the structure is favorable for the accumulation of oil, that is, localities where the strata have been folded into anticlines, synclines, domes and basins. This he must do by the careful mapping of the area and the plotting of all the exposures and the direction of the dip in every instance. In certain regions the formations are so well exposed that he can trace a single stratum all over the area he plans to map. This he considers his key bed and by the use of the plane-table and telescopic alidade he determines and maps the elevation of the bed at many points. He then draws contours based upon these elevations by which he portrays the structure of the key bed exactly as a topographic map portrays the character of the surface of the ground. (Fig. 2).

Structural Features and Topographical Features.—In this connection one must clearly distinguish between structural and topographical features. Sometimes there may be a relationship between the two, but more often they are wholly independent. It more frequently happens that an anticline, especially when it is a pronounced fold, is represented by a valley than a ridge. Jones Valley and Brown's Valley are both anticlines, and on the other hand, synclines are often represented by ridges or areas of relief. Hard resistant formations may sometimes stand out as distinct topographical features (Fig. 10). If the formation is horizontal the resultant feature will be a flat-topped hill or mesa; if gently inclined it may form an extended ridge or cuesta with one abrupt and one gentle slope, corresponding more or less closely with the dip of the formation; if steeply inclined it may form a pronounced ridge with approximate symmetrical slopes, which is termed a hogback. Such correspondence however, between topographical and structural features is the exception rather than the rule, usually there being no indication of the structures, as determined by plotting of the dip and strike at many points, in the topography of the area.

THE SURFACE INDICATIONS.

We see, therefore, that the geologist does not base his conclusions upon surface indications, except in so far as the exposures indicate the structure of the underlying formations. He realizes that the formation that happens to form the surface in the area under consideration may be wholly dissimilar to the concealed formation that he considers a possible oil horizon. There are, however, certain indications that may impress the geologist either favorably or unfavorably in drawing his conclusions.

Oil and Gas Seeps.—The most important of the favorable indications is the occurrence of definite oil or gas seeps in the area under consideration. If there are actual seeps

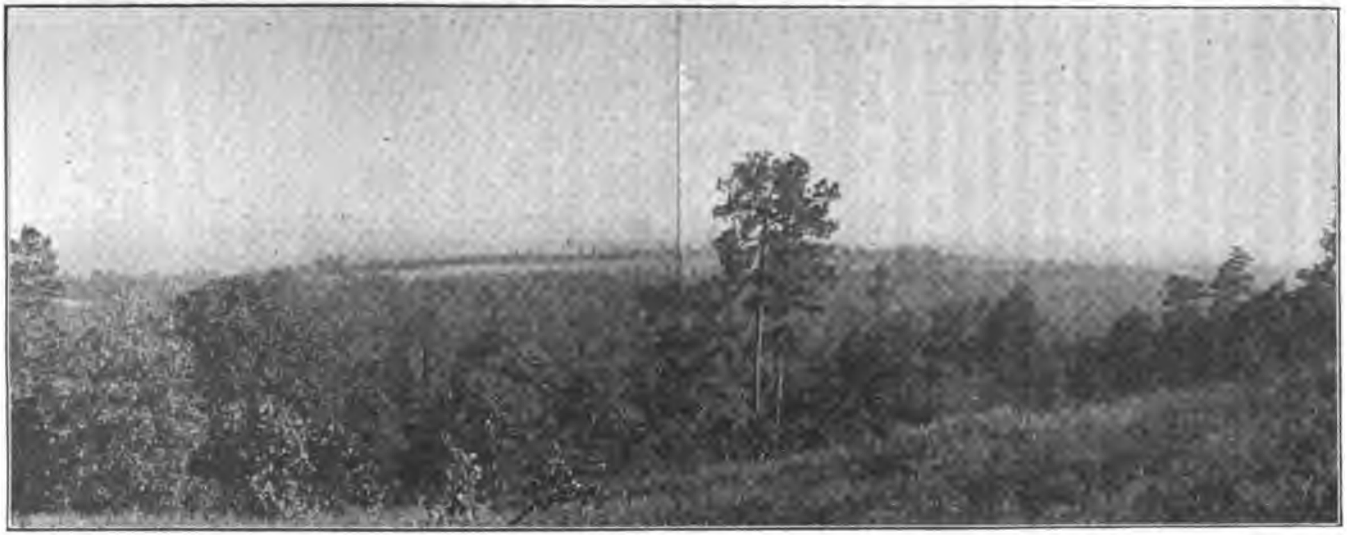

FIG. 10. The Aldrich Dome southeast of Birmingham showing the relation of structure to topography. The capping sandstone is the Millstone Grit while the upper conglomerate or Pine sandstone completely encircles the structure, forming an infacing escarpment. (Courtesy T. H. Aldrich, Jr.)

in the locality they would at least indicate that the series is petroliferous, and therefore the prospects good, if well-defined structural traps can be found. Unfortunately most reported seeps are not real oil seeps, but may be a number of other things. The most common material mistaken for oil scum is the film of iron oxide (limonite) that is frequently seen on stagnant waters. An iron scum can be readily recognized by the following test: Take a twig and immerse it in the scum-covered water; if the scum breaks up and cracks develop in it, it is iron oxide; if no cracks develop and the hole made by the twig immediately closes it may be oil. A further test is to rub some of the scum on the fingers and then try to wash it off. If it washes off readily it is not oil, but if it cannot be washed off, it probably is oil. In certain regions algae form scums on the water that greatly resemble heavy oil. In East Texas the writer has seen scums of black or greenish black algae that would readily be mistaken for heavy asphaltic oil. The simple test of rubbing it on the fingers and then washing it off, however, immediately shows that it is not oil.

Likewise bubbles of air, carbon dioxide, and hydrogen sulphide may be mistaken for true seeps of natural gas. A combustion test or chemical analysis should be made of the material before it is pronounced a natural gas seep.

In highly folded and faulted areas where there is no possibility of oil or gas accumulation in commercial quantities oil and gas seeps may occur, representing the final stages in dissipation of the petroleum content of the folded series. In Alabama, for example, the Trenton limestone and the Knox dolomite in the Coosa Valley region show occasional oil and gas seeps and the Trenton limestone sometimes shows petroleum saturation or impregnation on the outcrop. These shows, however, do not indicate that there are commercial deposits of oil or gas below, but that the intensity of the deformation has driven off the more volatile constituents leaving only the heavier asphaltic constituents as a residual impregnation at the surface. In such a region commercial pools though formerly present, would not survive the deformation to which the area has been subjected in later geologic time, and only occasional saturated areas and seeps remain until the present to indicate the former existence of greater petroleum content or possible important accumulations.

Salt Water Wells and Artesian Wells.—Strong flows of salt water in the deeper wells of any locality may be considered an unfavorable indication as the presence of abundant salt water would indicate that the reservoirs were completely filled with water to the exclusion of oil. A strong flow of salt water in a well drilled on favorable structure would certainly warrant such a conclusion. Artesian wells are usually found in synclines and structural basins, where hydrostatic pressure is sufficient to cause a flowing well. The structural conditions necessary to artesian flow are in the main opposite to those necessary to oil accumulation. Therefore one would not expect to find favorable oil structures in the immediate vicinity of artesian wells.

FACTORS OF NO SIGNIFICANCE.

There are certain phenomena sometimes erroneously considered oil signs by the laity, but which in fact have no significance. We have seen that topography, except in certain areas where the dip slope can be seen, is no index to petroleum territory. Oil fields occur beneath flat plains, rolling hills, and even rugged and mountainous topography. Likewise elevation is of no significance. In the Rock River field of South Wyoming the oil-bearing horizon is 5,000 feet above sea level and at Goose Creek, Texas, the wells starting at sea level, get their production from 3,000 feet or more below. Climate is also unrelated to oil territory, even though there is the suggestive fact that the major oil fields are found between certain limits in latitude and annual temperature, but oil fields of less importance have been developed in the tropics and in the comparatively frigid temperature of Alberta. Likewise they are to be found in deserts, in swamps, and in fertile plains.

Vegetation is another factor of no significance strictly speaking. However certain rock types can be recognized by the vegetation upon them. In north central Texas, for instance, limestone-capped hills can be readily recognized as such from a considerable distance by the mesquite and live oak that apparently favor the limestone soil. In other localities formation can be traced great distances by the vegetation that grows upon their outcrops. In this way the vegetation may be helpful in working out the structure of an area, but it does not in any way indicate the presence or absence of oil in the underlying sediments. Other factors of no significance are the kind of surface rock, the abundance or scarcity of certain colored pebbles, or any other kind of loose material, shells, fossils, and so forth. All of these features are wholly unconnected and unrelated to the underlying formations in which the oil must occur.

THE VALUE OF GEOLOGICAL EXAMINATION.

The actual value of geological examination has been much disputed by operators, particularly in the earlier days when the geologist knew little regarding the conditions necessary for the origin and the many factors that influence the accumulation of oil. With the development of modern ideas and theories, which have been in great part proven by actual experience, the expediency of a preliminary geological examination has been more and more appreciated by the far-sighted operators, and at present practically every large and progressive oil company has an established geological department and a corps of geologists. Indeed at present the petroleum geologist depends solely on the operators for employment, as the land owner is not yet educated to the value of a geological examination and is unwilling to pay the necessary cost. It is not the excitable land-owner that is willing to pay the comparatively high fees of the consulting geologist to determine the value of his land, but the hard-headed operator, whose common sense shows him that the cost of geological examination is negligible as compared with the cost of a test, and if it in any degree increases the possible chance of success it is well worth while.

Unfortunately in Alabama, as in many other wildcat territories, much money has been wasted by lack of intelligent geological advice. Though numerous wells have been sunk in all parts of the State only three or four have been located upon the recommendation of reputable geologists. Undeveloped territory is the playground of the promoter whose chief object is the mulcting of the natives, and whose last idea would be the conscientious development of producing territory. The future, however, is more promising. Large companies are entering the field and the locations of future tests will be determined upon the evidence obtained by exhaustive and detailed geological study.

THE OUTLOOK IN ALABAMA.

On the whole the future prospects for Alabama are promising. There occur in certain parts of the State sediments that meet all the requirements for oil production and a variety of favorable structures occur throughout many parts of the State, which should bring about the accumulation of the oil originating in the petroliferous strata. In these series are also found formations, some of which have a high percentage of pore-space, and which should make good reservoir rocks. So it can be seen that it simply remains to find these localities where all the conditions are favorable and there make sufficiently deep tests. In the past only one or two such tests have been made, so the failures of the past should be no discouragement for the future.

Geologically Alabama is readily subdivided into three provinces; in the first of which oil accumulation in commercial quantities would be impossible; in the second such accumulation would be very improbable; and in the third commercial accumulation would be possible, and in certain favorable localities even probable.

Impossible Area.—In the following counties commercial accumulation of oil is considered impossible:

Chambers,
Chilton,
Clay,
Cleburne,
Coosa,
Elmore,
Lee,
Randolph,
Tallapoosa,
Talladega (in part).

Improbable Area.—In the following counties, lying in the areas where the chance for commercial production is very improbable, it would not be wise to spend money in prospecting:

Autauga,
Barbour (in part),
Bibb,
Blount,
Bullock,
Calhoun,
Cherokee,
Dallas,
DeKalb,
Etowah,
Greene,
Hale,
Jackson,
Jefferson (in part),
Limestone (in part),
Lowndes,
Macon,
Madison (in part),
Marengo (in part),
Marshall,
Montgomery,
Perry,
Pickens,
Russell,
Shelby,
St. Clair,
Sumter,
Talladega.

The following counties should also be classified with improbable territory, because loose gravel and other unrelated surface formations completely conceal the petroliferous strata below, making it impossible to determine the geological structure of these areas:

Baldwin (in part),
Lamar (in part),
Mobile,
Pickens,
Tuscaloosa (in part).

Possible Area.—The counties in which production is possible are the following:

Baldwin (in part),
Barbour (in part),
Butler,
Choctaw,
Clarke,
Coffee,
Colbert,
Conecuh,
Covington,
Crenshaw,
Cullman,
Dale,
Escambia,
Fayette,
Franklin,
Geneva,
Henry,
Houston,
Lamar (in part),
Lauderdale (in part),
Lawrence,
Marengo (in part),
Marion,
Mobile (in part),
Monroe,
Morgan,
Pike (in part),
Tuscaloosa (in part),
Walker,
Washington,
Wilcox (in part),
Winston.

THE GEOLOGICAL PROVINCES OF ALABAMA.

The subdivision of the State of Alabama into the three provinces given above; namely the impossible territory, the probable territory and the possible territory, is based upon the nature of the geological formations developed in each province. This classification can be carried a step further and the State subdivided into eight distinct provinces in each of which the geological conditions are either slightly or entirely dissimilar, giving rise to eight territories in which the possibilities for oil and gas would vary according to the nature and structure of the rocks involved. On the accompanying outline map of the State (Fig. 11) these provinces are shown. As can be readily recognized the boundaries of the provinces usually roughly coincide with boundaries of the different geological formations. In some cases, however, the boundaries follow changes in structure rather than differences in the age of the formations. Moreover, as the subdivision of the State into these provinces is purely from the point of view of possible oil and gas production the boundary lines are indefinite and even though they generally correspond with those of the geological formation they do not necessarily do so.

Province One.—Impossible territory. The crystalline area composed of rocks of pre-Cambrian age in most parts, which are so highly metamorphosed that neither oil nor gas accumulation is possible.

Province Two.—The Paleozoic area of highly folded and faulted sedimentary rocks, extending as far northwest as the sixty-five per cent. isovolve (Fig. 15), and southwest until overlapped by the Cretaceous formations. This area represents the southern end of the folded Appalachian mountains, and it can be considered as an extremely improbable territory for oil accumulation. The accumulation of gas, however, is possible, and the development of small pools can be expected throughout the more favorable portions, from a structural standpoint, of the entire area.

Province Three.—The Plateau Region and the Tennessee Valley; a province of approximately horizontal or gently warped Paleozoic sediments comprising a petroliferous series in which there are four or five distinct potential oil and gas horizons. This area is probably the most favorable for oil and gas production that is to be found in the State. The situation of this province near the top of the Cincinnati Uplift is an additional favorable feature.

Province Four.—That portion of the Plateau Region where the petroliferous series, that is, the Paleozoic sediments, is concealed by the unconformable cover of the gravels and clays of the Cretaceous formations, so that it is impossible for the geologist to determine the structure of the formations in which the oil if present will occur. The eastern boundary of this province is indefinite, as in this area the Cretaceous sediments cover the upland areas while the Paleozoics are exposed along the streams. The possibilities for oil and gas accumulation in this province are the same as in number three, but owing to the additional cover drilling will have to be continued deeper and prospecting carried on by wildcatting, strictly speaking.

Province Five.—Impossible territory. That southernmost tip of the folded Appalachian mountains which is covered by the overlapping Cretaceous strata. This province is considered impossible territory because the petroliferous series, the Paleozoic formations, are not only intensely

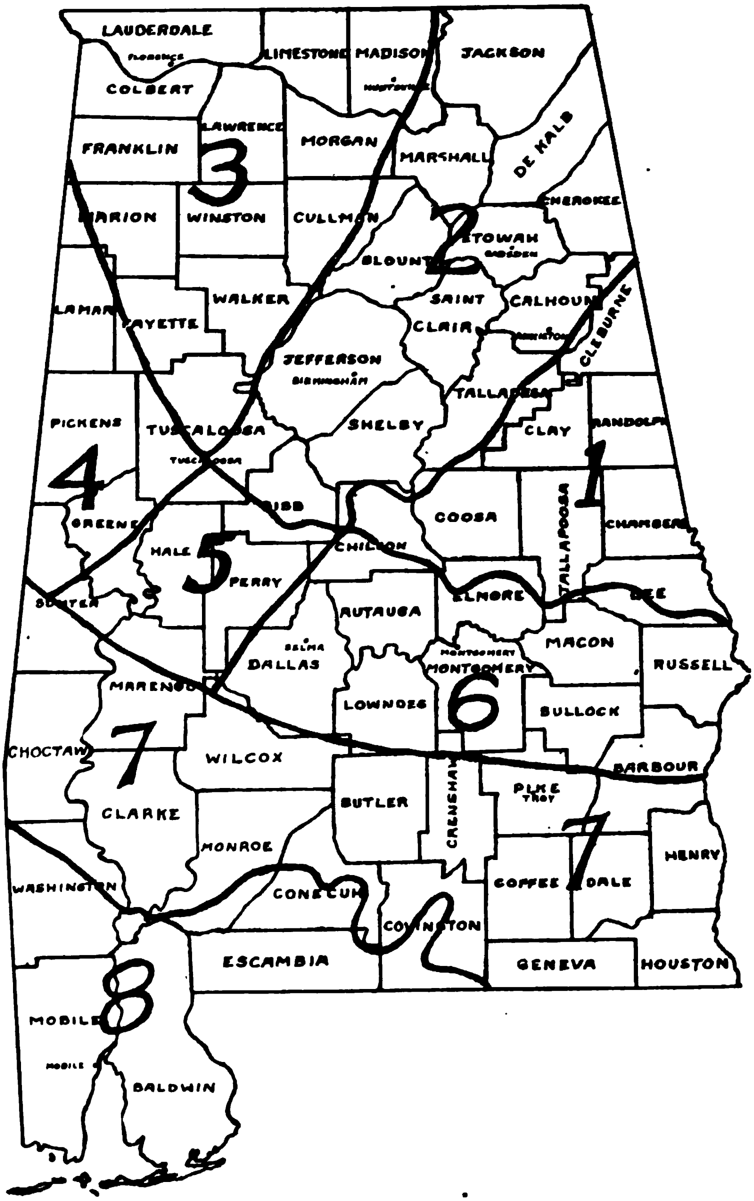

FIG. 11. Outline map of Alabama showing the eight geological provinces. Provinces 3 and 7 constitute the more probable oil-producing territory of the State.

folded and faulted but are wholly concealed by an unconformable cover.

Province Six.—Impossible territory. The metamorphic rocks of the crystalline area (province 1) which are covered by the overlapping Cretaceous formations. As the Cretaceous formations in this province do not show the characteristics of a petroliferous series where sufficiently covered to entrap oil they can be eliminated as a possible oil producing series, and beneath them in the crystalline rocks oil accumulation is likewise impossible.

Province Seven.—A region of Tertiary sediments dipping gently to the south and overlying conformably a series of Cretaceous formations, which as developed in depth in this province show many of the characteristics of petroliferous series. The Cretaceous series is of marine origin and is locally folded so that structures favorable for the accumulation of oil and gas are developed, and these structures can be recognized as such by the geologist making an examination of the area. It is possible, however, that these sediments contain insufficient animal and plant remains to generate commercial quantities of petroleum. This province together with province 3 comprises the favorable oil territory of Alabama.

Province Eight.—A region in which the geological conditions are the same as in province 7, except that the petroliferous series is more deeply buried (2,000 to 5,000 feet), and the surface is formed by unconsolidated material, so that the geologist is unable to locate definite structure and development must be brought about by wildcatting.

GEOLOGICAL CROSS-SECTIONS OF NORTH ALABAMA.

The valuable and instructive cross-sections that were made by Henry McCalley some time ago to accompany his Report on the Valley Regions of Alabama have been reproduced for this report (Plate II inside back cover). These cross-sections, on account of their accuracy and great detail, should be of inestimable value to the future prospector as well as the landowner in giving them at a glance the general features of the structure in all parts of northern Alabama. On the accompanying index map (Fig. 12) the locations of the sections that are referred to by number on

Plate II are given. At the time the manuscript was written the reproduction of these sections was not contemplated, and so reference to them in the text has not been made so frequently as their real value would warrant.

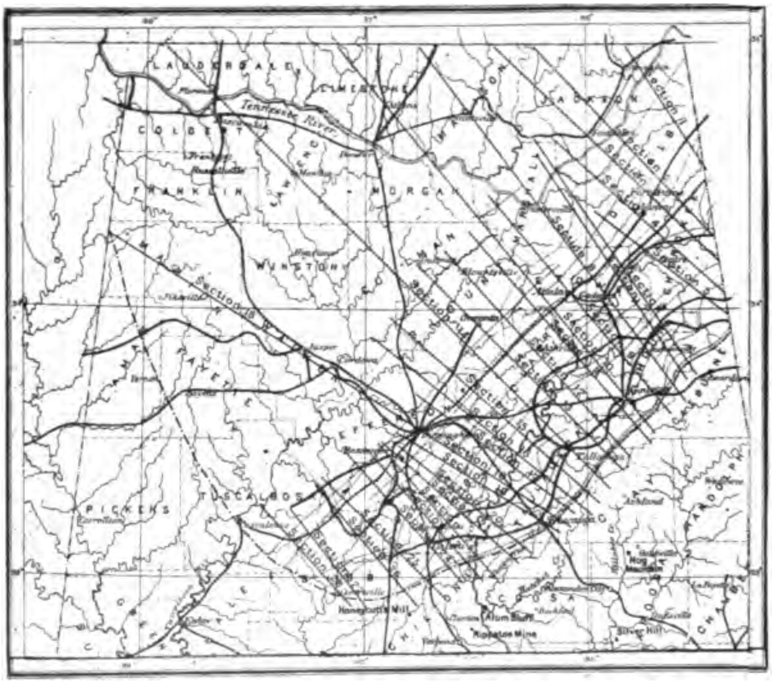

FIG. 12. Index map of Northern Alabama showing the locations of the sections shown on Plate II (in pocket inside back cover).

ACKNOWLEDGMENTS.

The writer wishes to acknowledge his indebtedness to the many who have contributed information, suggestions and well logs that have added to the completeness of this report. He is especially grateful to the State Geologist, Dr. Eugene A. Smith, for much helpful information regarding the geology of the State; to Dr. Stewart J. Lloyd, of the University of Alabama, formerly Inspector of Oil and Gas Wells, for the use of numerous well logs; to Mr. S. A. Hobson, of Birmingham, for many logs and helpful information regarding the past development in the State; to Dr. R. M.

Harper, Geographer of the Geological Survey, for helpful criticism and proof-reading; to Mr. R. S. Hodges, Chemist of the Geological Survey, for numerous analyses of coal and oil, and to Mr. W. B. Jones, of the University of Alabama, for assistance in the field work.

The writer is likewise indebted to the various companies and other individuals that have so kindly supplied the locations, logs and results of the wells that have been drilled and are being drilled throughout the northern part of the State.

PART I

NORTHERN ALABAMA*

THE possible oil territory of Alabama can be readily divided into two regions, the Paleozoic area of the north,** and the Coastal Plain province of Cretaceous and younger formations lying to the south. These two provinces will be treated separately in the present bulletin. The northern province will first be discussed as a whole and then by counties.

Topographically, as well as structurally, the Paleozoic area can be divided into three rather well-defined provinces: (1) The broad, open Coosa Valley lying adjacent to the crystalline oldland, with comparatively little relief, except for occasional longitudinal ridges and rather intense folding; (2) the plateau region of horizontal or gently warped Pennsylvanian strata broken by occasional anticlinal valleys aligned northeast and southwest, outliers of the Coosa Valley proper, in which the older Paleozoic formations are exposed—a region of much relief (200 to 300 ft.) and thorough dissection, well wooded, and of little agricultural importance; and (3) the Tennessee Valley region of horizontal or gently warped Pennsylvanian and Mississippian strata, where the relief is not so marked, the wooded area is less extensive, and the country is of more importance agriculturally.

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* In the discussion of the general features and oil possibilities of this area the writer has drawn freely from a paper recently published by him and quoted below.

** Among the more important references on the geology, physiography, and economic resources of northern Alabama are:

Henry McCalley: Natural Gas and Petroleum in North Alabama. Proc. Ala. Industrial and Scientific Soc., Vol. 1, No. 1, pp. 35-48 (1891).

Henry McCalley: Report on the Valley Regions of Alabama. Part 1, The Tennessee Valley Region; Part 2, The Coosa Valley Region. Geological Survey of Alabama (1896).

Henry McCalley: Report on the Coal Measures of the Plateau Region of Alabama, Geol. Survey of Alabama (1891).

Henry McCalley: Report on the Warrior Coal Basin, Geol. Survey of Alabama (1900).

M. J. Munn: Reconnoissance Report on the Fayette Gas Field, Alabama. Geol. Survey of Alabama, Bull. 10 (1911). Also published under the title: The Fayette Gas Field, Alabama. U. S. Geol. Survey, Bull. 471, pp. 30-55 (1910).

R. M. Harper: Economic Botany of Alabama. Part I, Geol. Survey of Alabama (1913).

Eugene A. Smith: Historical Sketch of Oil and Gas Development in Alabama. Oil Trade Journal, Vol. 9, p. 133 (April 1918).

D. R. Semmes: Oil Possibilities in Northern Alabama, Min. & Met., No. 159 (March, 1920).

STRATIGRAPHY.

The following generalized section gives an approximate idea of the thickness and lithologic character of the formations of the region as a whole. The Carboniferous series, especially, shows lateral variations of striking prominence, but certain horizons are persistent throughout the area.

STRATIGRAPHIC SECTION FOR NORTHERN ALABAMA

Age	*Formation Name*	*Thickness*	*Lithologic Character and Subdivisions*
Pleistocene Pliocene	Lafayette	0– 50	Unconsolidated and semiconsolidated gravels and sands. Red, pinkish, maroon, and whitish clays.
Cretaceous	Tuscaloosa	0–1000	Gravels, sands, and clays. Red to gray or white. Non-marine.
Pennsylvanian	Coal measures	200–2500	Shales, arenaceous shales, massive sandstones, and conglomerates near base. Basal conglomerate, or Millstone grit. Coal seams.
Upper Mississippian	Mountain limestone	400– 900	Massive bluish crinoidal limestone (Bangor limestone), overlying a series of coarse to medium-grained sandstones with alternating thinner beds of limestones and shales. Thick, locally massive, brown sandstones at base (Hartselle sandstone).
Lower Mississippian	Fort Payne chert	200– 500	Cherty limestone or limestones with thin chert seams or layers of nodules. Readily eroded, valley-making formation (Tuscumbia limestone). This overlies a series of hard cherts (Lauderdale chert), very resistant to erosion and forming prominent ridges.
Devonian	Black shale	0– 50	Black, highly bituminous shales and locally thin sandstones and bluish shales.

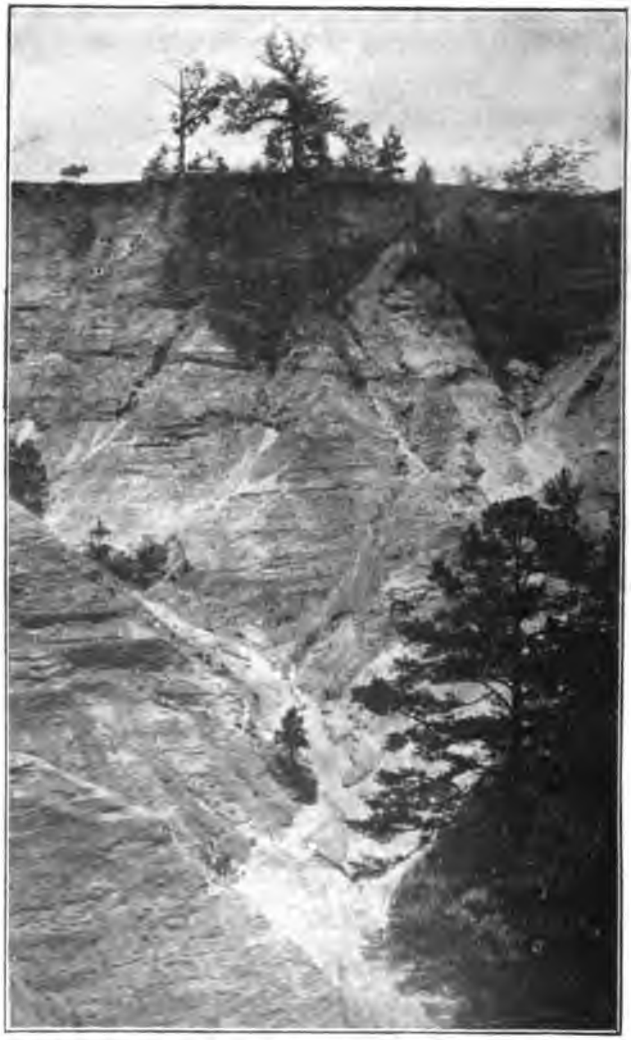

FIG. 13. Extensive gully formation in the Tuscaloosa clays, (near Saunder's Ferry, Tuscaloosa County), which cover the Coal Measures along the northwestern line of the State. (Photo by R. M. Harper.)

Age	*Formation Name*	*Thickness*	*Lithologic Character and Subdivisions*
Silurian	Clinton	200– 400	Shales, limestones (Niagara), and ferruginous sandstones and some conglomerates. Iron ores.
	Unconformity (?)		
Ordovician	Trenton limestone	500–1000	Bluish, thin-bedded limestone (Pelham or Chickamauga) with coarse-grained siliceous layers, making excellent oil sands.
	Unconformity		
	Knox dolomite	2000–3300	Sharply folded and faulted thick - bedded crystalline dolomite with chert seams, overlying 600 ft. of thick-bedded non-cherty gray crystalline dolomite.
Cambrian	Coosa shales	1000–1500	Thin-bedded blue limestone and gray and yellow shales.

Of these formations the Carboniferous formations cover much of the larger part of the whole region, the Pennsylvanian, or Coal Measures, forming the surface throughout large portions of Cullman, Winston, Walker, Blount, Jefferson, and Tuscaloosa Counties, and the Mississippian forming the surface in Madison, Limestone, Lawrence, Lauderdale, and Colbert Counties. To the west, the Carboniferous strata are overlapped by the Cretaceous, which in turn is covered in places by the Lafayette, but throughout a large part of this Cretaceous area the underlying Coal Measures are exposed along the courses of the principal streams. The pre-Carboniferous rocks are only exposed in small areas in the north, along the anticlinal valleys farther south, and in the Coosa Valley.

OIL AND GAS HORIZONS.

The possible oil and gas horizons throughout the section are rather numerous; many of these horizons have, locally, given very promising shows. Owing to the striking lateral variations in lithologic character, horizons that may at one point be promising have little or no possibilities at another; this is especially true in the Carboniferous series.

PENNSYLVANIAN HORIZONS.

In the Fayette gas field in Fayette County, the wells encountered the first shows at about 500 feet (152 m.) below

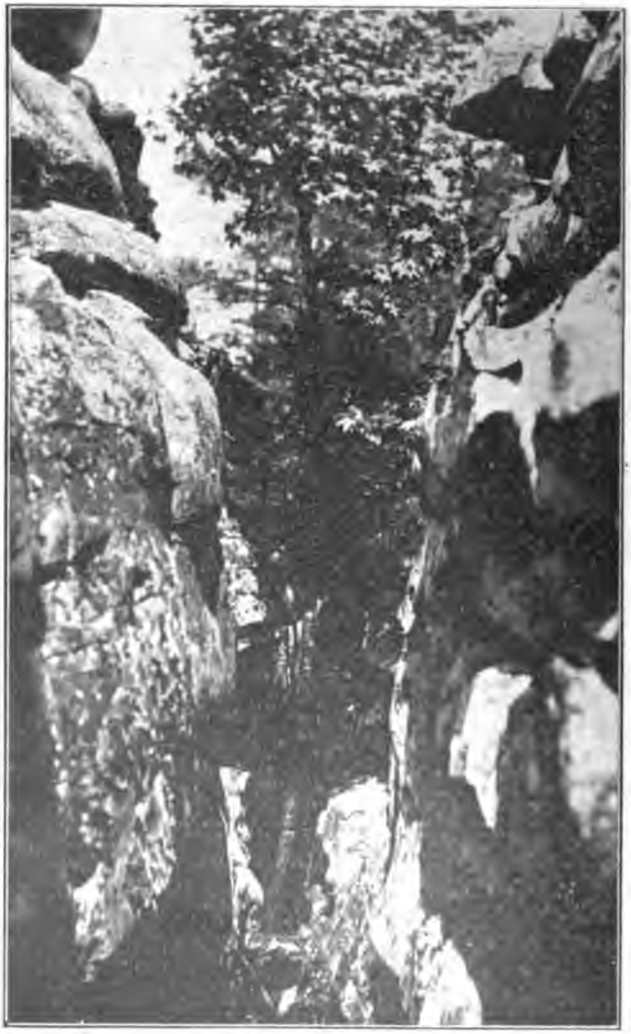

FIG. 14. Crevices in the Millstone Grit (Eight-acre Rock, Tuscaloosa County) showing the massive character of this formation. The sandstone as a whole is a poor oil horizon, but porous horizons in it may prove productive. (Photo by R. M. Harper.)

sea level, or at a depth of from 850 to 950 ft. (259 to 289 m.). This sandstone, though giving good shows of oil, proved of no value and the wells were continued 500 ft. lower and there encountered the Fayette gas sand proper, a soft, white sand of excellent quality. The best well of this group was estimated at 4,000,000 cu. ft. (112,000 cu. m.), per day. At other points, the sand was found more tightly cemented and proved less productive. About 200 ft. below the Fayette sand a thick sandstone (250 ft.) was encountered, which also gave gas shows and is locally known as the Second Gas sand. Drilling has been continued 900 ft. below the Fayette sand and another thick sandstone, containing salt water, was encountered near the bottom. This sandstone has been correlated with the Pine sandstone member of the Birmingham Folio,* in which case the Fayette sand should be underlain by some 1,000 ft. of shales and massive sandstones to the base of the Pine sandstone, then 500 ft. of shales and shaly sandstones, and finally 500 ft. more or less of massive sandstones with conglomerates at the base (Millstone grit). In other words, the Fayette gas sand should be about 2,000 ft. above the base of the Pennsylvanian, if maximum thicknesses were represented. Deep borings in the area have shown, however, that the total thickness of the Pennsylvanian is not over 2,300 ft., or only about 1,000 ft. of sediments underlie the Fayette sand.

The two basal sandstones of the Coal Measures, the upper and lower conglomerates, or the Pine sandstone and the Millstone grit, can be considered as possible oil horizons, but owing to their great thickness, thorough cementation, and massive character, as well as the fact that they have no adequate source of oil below, the writer would not consider them horizons worthy in themselves of extensive testing. (Fig. 14.)

Mississippian Horizons.

As early as 1865, wells were drilled in Lawrence County in the vicinity of asphaltum and maltha showings in Mississippian strata, and the majority of all such occurrences of bitumen, maltha, and asphaltum that have been reported since are in these formations. In the Bangor limestone, many such occurrences have been found and it is not unreasonable to suppose that a sandy layer in this limestone might prove a paying oil sand. Below the Bangor comes the Hartselle group of thick sandstones and interbedded limestones. In Morgan, Lawrence, and Franklin Counties, numerous seeps have been found in the Hartselle, and, in many places, this group is found saturated with residual petroleum. In many localities this sandstone is coarse-grained and friable, with a large amount of pore space, which should make it an excellent oil sand; but elsewhere it is fine-grained and highly cemented and has so little pore space that it is improbable that it would prove a pay sand. Unfortunately, no good test has been made in this horizon as none of the wells started in the Pennsylvanian has reached this depth, while those started below the Pennsylvanian have usually commenced operations on the Hartselle itself, or immediately above it. The Lower Mississippian Tuscumbia limestone has given rather promising shows in certain recent tests. In it are found sandy horizons that, according to the driller's statement, make excellent oil sands. This limestone gave encouraging shows in the wells at Atwood and Frankfort in Franklin County and also in some of the tests made in Walker and Jefferson Counties. It should be regarded, therefore, as a potential horizon in any test located so as to strike it at a reasonable depth.

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* Folio No. 175. U. S. Geol. Survey.

TRENTON HORIZON.

The only well that has struck oil in commercial quantities in Alabama found it in the Trenton (Pelham) limestone. This horizon is, in the opinion of the writer, the most favorable for commercial oil and gas to be found in the northern part of the State. The Trenton series is composed of thin-bedded bluish and shaly limestones, throughout which there are horizons of coarse-grained, sandy limestones making good oil sands.

The Trenton limestone has given shows of oil and gas at many points in the northern part of the State. Besides the Goyer well in Lawrence County, in which commercial production was found in the Trenton, it has given good shows of oil in the well at Hartselle, Morgan County, the Atwood well, Franklin County, the Bryan well, Jefferson County and the Allen well near Florence, Lauderdale County. Good shows of gas were also found in the Trenton in the wells near Hazel Green, Madison County.

KNOX HORIZON.

The Cambro-Ordovician Knox dolomite has occasionally given small shows of gas; and since dolomitization with its attendant shrinkage should indicate increase in pore space and in capacity as a reservoir, this formation has been tested several times in the hope of its proving productive. But, as the Knox lies unconformably below the Trenton and where exposed shows a high degree of deformation, its possibilities for petroleum are so slight as to be unworthy of serious consideration.

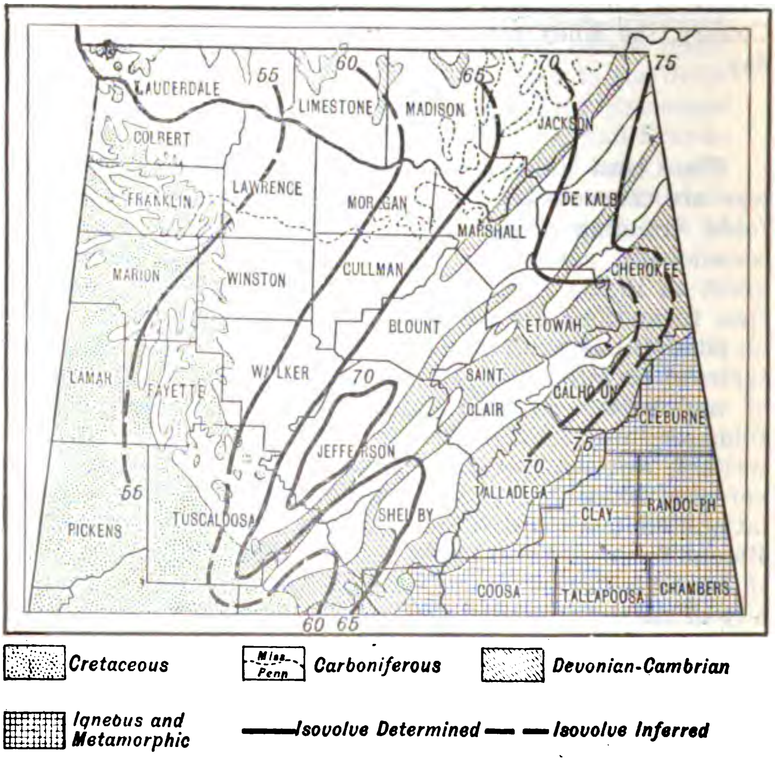
The possibilities of the Knox as a gas producer are good throughout the north and northwestern portions of the State. A small show of gas was found in the Knox in the Huntsville well, Madison County, and in the Frankfort well, Franklin County, and in the Haleyville well, in Winston County, the Knox produced some 40,000 cu. ft. of gas per day.

STRUCTURAL FEATURES.

The Coosa Valley region and the adjacent outlying valleys are characterized by a rather intense type of parallel folds, trending northeast and southwest, with which are occasionally associated faults showing displacements as great as 10,000 feet. In many of these folds, the Ordovician formations are exposed and they, consequently, have no possibilities as oil traps. In addition to the northeastern series of prominent Appalachian-type folds, there is a series of undulations running northwest and southeast. These folds, or "waves" as they have been termed by the earlier writers, are sometimes quite pronounced and show a reversal of 100 ft. or more. At the intersection of these undulations quaquaversal structures are formed, such as the Blount Springs dome, which should make excellent oil traps if the oil horizons themselves are not exposed. The intensity of the deformation of this area, however, is considered an unfavorable factor in the development of valuable accumulations of oil.

In the Plateau region, running parallel to the Appalachian folds farther east and south, there is a series of subsidiary undulations, which can be traced out in the beds of the Coal Measures. In this area are likewise developed the series of northwest-southeast waves, and at the intersection of these two series more or less perfectly developed domes are occasionally established. Unfortunately, the most favorable portion of the Pennsylvanian area, the western part, is rather extensively covered by the Lafayette gravels and the Cretaceous series, or by a mantle of residual soil, which makes the locating of favorable structures a difficult task; and after evidence of folding has been found, it is often impossible to map the structures in detail.

In the Tennessee Valley region, especially in the area underlain by the Mountain Limestone group (Morgan, Lawrence, Franklin, and Colbert Counties), the two series of undulations can be readily detected; and owing to the character of the surface rock the structure can be accurately mapped. Since the most favorable oil horizon, the Trenton,



GEOLOGICAL MAP OF NORTHERN ALABAMA, SHOWING CARBON RATIOS.

FIG. 15. Geological map of Northern Alabama showing carbon ratios. (Courtesy *Mining and Metallurgy.*)

occurs in this area at a depth of 1,000 to 2,000 ft., the area is considered very favorable for future prospecting.

SIGNIFICANCE OF CARBON RATIOS OF COALS OF AREA.

A recent paper by Fuller,* discussing the relation of the carbon ratios of the Pennsylvanian coals to the oil fields of northern Texas, has interested the writer in collecting and plotting the fixed carbon percentages of the Pennsylvanian coals of northern Alabama. In certain localities, a sufficient number of analyses were obtainable to locate the isovolves† definitely; in other areas, their location was largely inferred. On the accompanying map, the direct relationship between the fixed carbon and the amount of deformation is very apparent. Even such outlying folds as the Sequatchie anticline have their definite effect upon the percentage of fixed carbon in the coal mined along their flanks. The degree of metamorphism attending this deformation has been shown by David White‡ to be definitely related to the distribution and composition of the oils found in the formations affected. When metamorphism has reached such an extent that the fixed carbon in the coals, considered on a basis of pure coal, has reached a percentage of 70, it is very improbable that oil pools of commercial importance will be found. In the case of northern Alabama, the writer believes that all areas where the fixed carbon runs as high as 65 per cent. may be considered as unfavorable territory and unworthy of extensive tests, until at least the areas of lower percentages have been tested and oil found in paying quantities. An examination of the accompanying map shows that the 65-percent. isovolve becomes definitely fixed near Huntsville and swings southward and westward across Madison, Marshall, Cullman, and Blount Counties, and along the northwestern line of Jefferson County, thence across Tuscaloosa County, swinging around the southwestern end of Jones' Valley anticline into Shelby County, thence southward again following the crystalline area. Farther east, the 70-per cent. and the 75-per cent. isovolves swing around the areas of more intense folding and attendant metamorphism. To the north and west of the 65-per cent. isovolve, the 60-per cent. isovolve is less definitely located; and owing to the scarcity of analyses of the coals of Marion and Franklin Counties, the location of the 55-per cent. isovolve is in part inferred.

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* Myron L. Fuller: Relation of Oil to Carbon Ratios of Pennsylvanian Coals in North Texas. Econ. Geol., Vol. 14, pp. 536-542 (June, 1919).

† The term "isovolve" has been adopted by Fuller, in the paper first cited, to signify a line drawn through points of equal carbon ratio.

‡ David White: Some Relations in Origin Between Coal and Petroleum. *Jnl.* Wash. Acad. Sci., Vol. 6, pp. 189-212 (March 16, 1915).

David White: Late Theories Regarding the Origin of Oil. *Bull.* Geol. Soc. Amer., Vol. 28, pp. 727-734 (Sept., 1917).

FAVORABLE AREAS.

If we are to consider the relation between metamorphism and oil distribution and composition as established, we are led to the conclusion that all the Coosa Valley region and much of the Plateau Region is unfavorable territory, and would expect in this area only small accumulations of light oil. West and north of the 65-per cent. isovolve there should be better chances for larger accumulations, provided we have the other necessary requirements of favorable section and structure.

The Pennsylvanian series shows a fairly favorable section, several good sands, and good structure where it can be worked out. Most of the area underlain by the Coal Measures lie within the 65-per cent. isovolve; to the west, the Coal Measures are covered by the Lafayette and Cretaceous formations. In the Fayette district, which is near the 55-per cent. isovolve, only gas was found in paying quantities, which would indicate that the degree of metamorphism was still too great for accumulation of oil. Considering, therefore, all evidence obtained so far, the Pennsylvanian area is not considered favorable territory except toward the western line of the State. In this area a hole drilled to 2,500 or 3,000 ft. would test the Hartselle sandstone as well as the Pennsylvanian horizons.

To the north, the Pennsylvanian formations break off forming a pronounced scarp facing the north. Passing down over this scarp, one comes upon a fairly level plain underlain by the lower members of the Bangor limestone. The upper, more massive members of this limestone form the base of the scarp. Farther north, beyond the plain underlain by the lower Bangor limestone, another scarp is formed by the Hartselle sandstone, locally known as Little Mountain. Between these two scarps there might be found favorable structure, where the Hartselle is sufficiently covered to prove productive; this area is rather limited, however, for which reason practically no tests have been made of the Mississippian horizons.

By drilling at any point north of the Pennsylvanian scarp, the upper Trenton horizons (Goyer horizon) would be encountered not more than 2,000 ft. (609 m.) in depth. This would give a large territory comprising most of Morgan, Lawrence, Colbert, and parts of Franklin and Lauderdale Counties, in which the type of structures commonly considered as oil traps are fairly abundant, the degree of metamorphism is comparatively low, and the section is decidedly favorable. It is this area, and especially in Franklin, Colbert, and Lawrence Counties, that the writer would suggest that future tests be made. Numerous anticlinal folds can be found in the Hartselle sandstones and in places definite closure can be worked out.

PAST AND PRESENT DEVELOPMENT.

The past and present development of oil and gas prospecting and the results obtained together with the logs of the more important tests are discussed in detail in the county descriptions that follow. The following is a chronological list of the outstanding tests that have been made in northern Alabama. The logs and descriptions of these wells can be found under the respective counties:

1865. Watson wells, southeastern Lawrence County; good shows in two wells; Trenton horizon.

1890. Newmarket well, Madison County; strong petroleum odor, but no sand; Trenton horizon.

1891. Goyer wells, southeastern Lawrence County; one estimated at 25 bbl. a day; Trenton horizon.

1893. Allen wells, Florence, Lauderdale County; one dry, the other showed small quantities of very light oil and some gas, well spoiled by shooting; Trenton horizon.

1904-5. Huntsville and Hazel Green, Madison County; gas shows at both localities; Trenton horizon.

1909. Fayette wells, Fayette County; one estimated at 4,000,000 cu. ft. of gas; Pennsylvanian horizon.

1910-11. Shannon wells, Jasper, Walker County; 50,000 cu. ft. of gas, oil show; Pennsylvanian horizon.

1911-12. Woodward Iron Co., Russellville, Franklin County; small gas show in Knox dolomite (?).

1912. Bryan, Jefferson County; oil and gas show; Pennsylvanian horizon.

1916. Cordova, Walker County; good show, black residual oil; Pennsylvanian horizon.

1917-18. Atwood well, Franklin County; gas indications; Pennsylvanian horizon.

1917-18. Aldrich Dome wells, 6 mi. southeast of Birmingham, Jefferson County; gas shows; Pennsylvanian horizon.

1918. Guin well, Lamar County; oil shows in two sands; Pennsylvanian horizon.

1919. Hobson well, Frankfort, Franklin County; drilling at 1765 ft. (Dec.), small oil and gas shows; Trenton horizon.

The evidence of the above tests strongly supports the carbon ratio hypothesis, as all localities near the 65-per cent. isovolve showed gas and only small shows of oil. The heavy oil found at Cordova (26.5° Be). is an exception, but this was undoubtedly a pocket of residual oil, the lighter volatile constituents of which had been driven off.

FUTURE PROSPECTING.

The area the writer considers most favorable for future testing is the northwestern portion of the State, where the Trenton limestone would be the producing horizon. Even this area is not without its disadvantages. The degree of metamorphism increases not only near areas of deformation but in depth in any locality as is shown by the progressive increase of fixed carbon in the successively older coal beds in passing downward in a normal sedimentary series.* Therefore the degree of incipient metamorphism of the Ordovician and Cambrian limestones, once covered to great depths by the younger Paleozoic formations, may be much greater than is indicated by the Pennsylvanian coal, in which case commercial accumulations of oil would be improbable. For this reason the Knox dolomite is not regarded by the writer as a potential oil producer, even though its possibilities for gas production may be good.

Upon the whole, however, considering the structure, the lithologic character of the section, and the evidence of the carbon ratios of the overlying Pennsylvanian coals, the area is undoubtedly worthy of further tests, provided they be well located on carefully determined structure.

In addition to the northwestern corner of the State, the Coal Measures, where exposed in Winston, Marion, and Fayette Counties, should be well worth testing, especially where drilling is continued to sufficient depths to test the Hartselle and the Trenton horizons.

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* This principle now regarded as established is known as the law of Hilt (see Carl Hilt, Ann. Assn. d'Ingenieur de Liege, p. 287, 1873). It is subject to certain exceptions, but under normal conditions is universally applicable.

COUNTY DESCRIPTIONS

BIBB COUNTY.

GEOLOGY AND STRUCTURE.

Bibb County is located at the southern end of the highly folded and somewhat metamorphosed Coosa Valley region. Throughout most of the southern and western part of the county the folded Paleozoic formations are covered by the gravels and clays of the Tuscaloosa formation (Cretaceous), which effectually conceal the structure of these older sediments. Farther north the Coal Measures are uncovered and there they occur in a broken syncline. The high percentage of fixed carbon in the coal of this area indicates that there is very little possibility of oil production. However, small gas pools might be found in the sands of the Coal Measures where the structure is favorable. Between Centerville and the Coal Measures to the north the older Paleozoics outcrop and even the possible oil and gas horizons are exposed, so that in this area there is no chance for production.

DEVELOPMENT.

Some diamond drill holes have been sunk in prospecting for coal and iron, but no oil or gas showings of consequence have been reported.

BLOUNT COUNTY.

GEOLOGY.

Blount County lies in the plateau or upland region separating the valleys of the Coosa and the Tennessee. The Coal Measures form the surface throughout the county except for two anticlinal valleys, which traverse the county from northeast to southwest. In Brown's valley, the northernmost of the two, the Paleozoic series as far down as the Silurian (Niagara) limestone is exposed in the valley floor. In Murphree's valley to the south the series as far down as the Knox dolomite is exposed. (Sections 11-15, Plate II.)

STRUCTURE.

The dominant structural features of the county are the two prominent Appalachian-type folds. The Brown's valley anticline, a southward continuation of the Sequatchee anticline, pitches gently to the southwest, with successively younger formations swinging around its southern end, so that the fold is covered by the Coal Measures just beyond the southern line of the county. The axis of the Murphree's Valley anticline is practically horizontal, except at its northern end where it pitches slightly to the northeast. Throughout its entire length the Knox dolomite is exposed, so that it offers no possibilities for either oil or gas.

In addition to these two very prominent folds there are other minor undulations that roughly parallel them. Moreover there is a separate and distinct series of folds developed almost perpendicular to the northeast-southwest series. These undulations or waves are not pronounced, but they can be readily detected by careful examination. At the intersections of these two systems favorable structures are sometimes formed. The Blount's Spring dome (Fig. 16) is a structural high point or node on the major Sequatchee anticline that probably lies at the intersection of this large fold and one of the less pronounced undulations developed at right angles to it. On Blount Mountain near the line between Blount and St. Clair Counties there is another anticline beginning at Greasy Cove and thence running southwest towards Sec. 3, T. 14 N., R. 1 E., some ten or more miles. This anticline is not breached throughout its development on Blount Mountain, so that structural high points or nodes developed along its axis would be favorable points for gas accumulation.

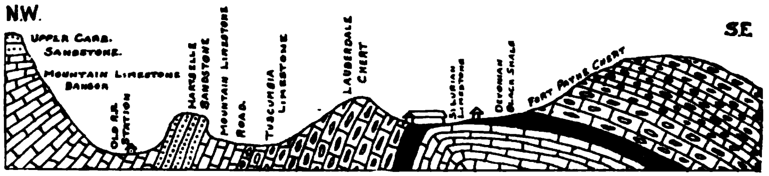

FIG. 16. Cross-section of the Brown's Valley anticline at Blount Springs showing the asymmetrical character of the Appalachian folds and the normal development of the middle and upper members of the Paleozoic series of Northern Alabama.

The folding so prevalent throughout the county is accompanied by faulting, which in some places involves extensive movements. The northern flank of the Brown's Valley anticline is faulted at Blount's Springs, and on the northern side of Murphree's Valley near Altoona the Coosa Shales are faulted against the Clinton, representing a movement of over a thousand feet.

DEVELOPMENT.

No tests made solely for oil or gas have been reported from Blount County though numerous holes have been drilled in prospecting for coal and iron. Some oil seeps have been reported, and in several places the rocks are locally saturated with petroleum.

CALHOUN COUNTY.

GEOLOGY AND STRUCTURE.

Calhoun County is underlain by highly folded and faulted, and in places highly metamorphosed sediments ranging in age from the pre-Cambrian to the Lower Carboniferous. Throughout the county the possible oil and gas horizons are repeatedly exposed and on the whole so greatly metamorphosed that there would be no chance for oil or gas accumulation in commercial quantities.

CHEROKEE COUNTY.

GEOLOGY AND STRUCTURE.

Cherokee County like Calhoun lies in the Coosa Valley proper, and only along its northwestern line do we find any of the upper Paleozoic formations still uneroded. Throughout the rest of the county the possible oil and gas-bearing formations are repeatedly exposed as well as highly folded and faulted. The coal from the northern part of the county, moreover, shows an exceptionally high percentage of fixed carbon (75 per cent.), so that the county as a whole can virtually be classed as impossible territory.

COLBERT COUNTY.

GEOLOGY.

Surface gravels and clays cover extensive portions of the southern and western part of this county. These gravels may be either Lafayette formation or Tuscaloosa formation, but in either case they effectually conceal the structure of the underlying Sub-carboniferous strata. Throughout the southern part of the county, in the stream beds, the Hartselle sandstone outcrops. The northern limit of the Hartselle is marked by a pronounced scarp, that continues eastward throughout the next two counties and is known as Little Mountain. North of Little Mountain the Tuscumbia limestone forms the broad flat floor of the Tennessee Valley, and this limestone has weathered leaving a heavy mantle of red soil, so that exposures throughout this area are comparatively scarce. (Section 14, Plate II.)

STRUCTURE.

In that portion of the county where the Hartselle sandstone is exposed the structure can be readily determined, and it is evident that folding is rather widespread. The prevalent types of structure are the northwest-southeast waves and occasionally cross-folds are found. One test is now being made across the south line of the county on one of these undulations. Throughout the area underlain by the Tuscumbia limestone the structure cannot be accurately determined, so development in this area must go on blindfolded.

DEVELOPMENT.

No tests for oil or gas have been reported from Colbert County. Numerous seeps and some tar springs have been found in the Hartselle sandstone region, and in some places this sandstone is impregnated with petroleum over extensive areas.

CULLMAN COUNTY.

GEOLOGY.

Cullman County lies almost wholly in the Plateau Region, the resistant beds of the Coal Measures forming a rather elevated, partially dissected plateau, that is locally termed Sand Mountain (to be differentiated from Raccoon Mountain also called Sand Mountain). Near the northern line of the county the Coal Measures plateau breaks off sharply, forming a pronounced scarp at the foot of which the strata of the Mountain limestone group reach the surface. (Section 14, Plate II.)

Analyses of the coals from Cullman County show that the fixed carbon runs rather high, about 64 per cent. Although this is not too high for oil accumulation it indicates that gas would be more likely to occur.

STRUCTURE.

The well-exposed series of the Coal Measures lends itself readily to the determination of the structure of the area. Folding is apparently widespread and the two distinct systems of folding that have already been mentioned are both evident; those folds aligned northwest-southeast, and those northeast-southwest.

DEVELOPMENT.

No wells drilled for oil have been reported, but several water wells were drilled in the vicinity of Cullman, one reaching a depth of 1,320 feet. No oil or gas were reported from these wells.

DEKALB COUNTY.

GEOLOGY AND STRUCTURE.

Topographically and structurally DeKalb County is readily divided into three parts: Wills' Valley, a sharp anticlinal valley of the Appalachian type, and the two broad gentle synclinal mountains lying to either side; Sand Mountain to the northwest and Lookout Mountain to the southeast. In Wills' Valley the Knox dolomite is exposed and it, therefore, offers no chance for oil or gas production. The two adjacent mountains underlain by the Coal Measures are synclinal in general structure and the coal from these areas, moreover, shows a very high percentage of fixed carbon (75 per cent. or more), so that it is exceedingly unlikely that oil will be found in the county in paying quantities. (Sections 1-4, Plate II.)

ETOWAH COUNTY.

GEOLOGY AND STRUCTURE.

This county, lying mostly in the Coosa Valley, is underlain throughout most of its southern and eastern portion by the Coosa shales, which are stratigraphically lower than any known oil horizon, and so can be regarded as impossible territory. In the northern part of the county the Coal Measures occur in the southwest end of Lookout Mountain and in the northern end of Blount Mountain, but in these areas the degree of metamorphism as shown by the high fixed carbon percentages of the coal is so great as to preclude the possibility of oil in commercial quantities. (Sections 5-9, Plate II.)

DEVELOPMENT.

A well was drilled near Gadsden in 1919. The results of this test have not been ascertained, but considering the highly folded and faulted character of the Paleozoic series in this locality, only negative results could be expected.

FAYETTE COUNTY.

GEOLOGY.

The sandstones and shales of the Coal Measures underlie the entire extent of Fayette County, but they are exposed in only limited areas, for throughout most of the county the Tuscaloosa sands and clays form the surface, and it is only along the streams that the Cretaceous cover has been cut through and the Coal Measures brought to light. The Tuscaloosa series occasionally shows a thickness of several hundred feet, but is usually less than a hundred feet. The Coal Measures in the southern part of the county aggregate over three thousand feet in thickness, while in the north where the upper beds have been removed by erosion the Tuscaloosa may be separated from the Lower Carboniferous by only 1,000 feet of these sediments.

STRUCTURE.

The widespread cover of younger and unconformable formations makes it impossible to determine the structure of the Coal Measures in many areas by the study of the surface structure. In other places the Coal Measures are sufficiently exposed to enable the geologist to get the general structure even if he cannot work out the details. In these localities it can be seen that the strata of the Coal Measures show frequent warping and occasional faulting. It is undoubtedly true that structures favorable for oil and gas accumulation frequently occur in the county, but unfortunately they can only rarely be recognized.

The structure of the territory lying east of Fayette Courthouse, including the Fayette gas field has been studied carefully and a structural map has been published by the Geological Survey of Alabama.*

In those portions of the area included in this map where the Coal Measures are exposed they are seen to be frequently slightly folded. Several hypothetical domes were worked out, which have not yet been tested. It is evident, however, that folding is widespread in this area, even though it can rarely be recognized.

No coal analyses were obtained from Fayette County, but at Corona just over the eastern line of the county, the coals showed an average of 56 per cent. of fixed carbon, which should be sufficiently low to permit the accumulation of large pools of a good grade of oil. But on the contrary in the Fayette field some twenty miles west of this point only gas was found. In the opinion of the writer, however, this simply indicates that the original geological conditions were not favorable for oil formation, and not that subsequent deformation has made it impossible for oil once formed to be preserved and accumulated in commercial quantities.

DEVELOPMENT.

Development in Fayette County has been centered around the gas field, near the station of Gas Wells just southeast of Fayette, in the valley of the Sipsey river. In 1909 a diamond drill hole was put down at this point in search for coal. This hole reached a depth of 425 feet, encountering two sandstones with slight shows of oil. Encouraged by these indications a company was formed and two deep tests were made adjacent to the diamond drill hole. On December 20, 1909, one of these wells reached a gas-bearing sandstone at about 1,400 feet in depth and began producing at an estimated rate of 1,600,000 cubic feet of gas a day at a closed pressure of 630 pounds to the square inch. The original Eureka Company was merged with the Providence Oil and Gas Company, this first producer being known as the Providence No. 1. The other test located about 100 feet on the other side of the diamond drill hole was continued to the depth of 1,685 feet, but only small shows of oil and gas were encountered. After the discovery well several other tests were made in rapid succession. The Providence No. 8, completed about March 1, 1910, came in at an estimated rate of 4,500,000 cubic feet of gas a day from the same sand, proving to be the best producer in the field. The No. 6 came in April 15 of the same year, producing from two to three million cubic feet a day. The Providence No. 3, drilled about a half mile from the railroad station at Fayette, was continued to 2,200 feet with only a small show of gas. Providence No. 9 came in around a million cubic feet, but later turned to salt water. Since then a half dozen wells have been drilled within a few thousand feet of the proven field, and a score or more in other parts of the same general territory but all without success as far as commercial production is concerned. The Providence No. 18 was drilled about 4 miles due east of Fayette on the Lewis land to the depth of 1,986 feet with only small shows. The Providence No. 19 on the Newton farm to the north of the gas field drilled into the lower conglomerate (Millstone Grit) getting only a strong flow of fresh water. The log of this well is as follows:

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* Reconnoissance Report on the Fayette Gas Field, Alabama, by M. J. Munn, Geological Survey of Alabama, Bull. 10 (1911).

Log of Providence Well No. 19 on Newton Farm.

Thickness of strata *Feet*		*Total depth* *Feet*
45	Alluvium	45
65	Sand	110
130	Slate	240
3	Coal	243
112	Slate	355
2	Coal	357
58	Slate	415
45	Sand (showing of gas at 460)	460
40	Slate	500
30	Lime	530
40	Slate	570
20	Lime	590
85	Shale	675
30	Black lime	705
80	Sand	785
	At 765 small showing of salt water which soon exhausted.	
10	Black slate	795
95	Bluish lime	890
25	Slate	915
170	Sandy lime and slate	1085
35	Black slate	1120
25	Sand	1145
20	Sandy shale	1165
75	Sand (hole full of salt water at 1190 feet)	1240
100	Black lime	1340
45	Black and shelly	1385
215	Sand	1600
	Traces of oil at 1385 and small showing of gas. Hole filled with salt water at 1395 feet.	
75	Black lime	1675
95	Lime, sand and shells	1770
145	Sandy lime and slate	1915
	Show of gas at 1915.	
50	Sand	1965
25	Slate	1990
112	Sand	2102
	Strong flow of fresh water at 2065, overflowing hole at 2102.	

The Providence No. 25, one of the last wells to be drilled by this company was located quite near the discovery well. It also continued into the Millstone Grit and likewise got a flow of water.

Log of Well No. 25 on Sprinkle Farm, Providence Company.

Drilling commenced September 13, 1912; abandoned December 20, 1912.

Thickness of strata *Feet*		*Total depth* *Feet*
20	Soil	20
	Pieces of coal showing on spud.	
260	Sand	280
	Showing of oil at 210.	
90	Slate	370
75	Sand	445
	Showing of oil at 380.	
5	Slate	450
120	Black limey slate	570
40	Lime shells	610
90	Sandy shale	700
60	Shale and shells	760
40	Shale	800
45	Sand	845
35	Black lime	880
60	Shale	940
20	Sand	960
	Showing of oil first screw in this sand.	
80	Shale	1040
95	White sand	1135
155	Shale and shells	1290
25	Sand	1315
155	Black slate	1470
8	Black sand	1478
	This sand had slight petroleum odor.	
6	Black lime	1484
34	Lime, shells and slate	1518
105	Shale	1623
80	Sand	1703
	Salt water at 1640.	
25	Black sand	1728
77	Slate	1805
20	Shells	1825
20	Slate	1845
40	Sand	1885
5	Sandy shale	1890
50	Sandy lime	1940
10	Black sand	1950
40	Slate	1990
108	Sand (some water at 2000)	2098
77	Sandy shale	2175
15	Sand (water increasing)	2190

None of the wells of the Fayette district has been continued to sufficient depth to test the Hartselle sandstone. At Bankston, about 10 miles east of Fayette, the Freeman well of the Alabama Central Oil and Gas Company, after getting a good show of gas and small shows of oil in the Fayette sand, was continued downward with the intention of making a test of the Hartselle. One misfortune followed another, however, and finally the tools were lost just before the top of the Hartselle was reached and the well abandoned. As this is the deepest well in Fayette County and of much significance in showing the nature of the entire thickness of the Coal Measures in this locality its log is given in full herewith:

Log of Freeman Well, Bankston, Alabama.

Elevation 466 feet.

		Thickness	*Depth*
Tuscaloosa	Cretaceous sand	15	15
COAL MEASURES	Black slate	95	110
	Broken lime	75	185
	Black slate	85	270
	Coal	5	275
	Slate and shale	205	480
	Coal	3	483
	Fire clay	10	493
	Dark sand	40	533
	Slate	90	623
	Coal	5	628
	Fire clay	10	638
	Dark sand	35	673
	Broken lime	140	813
	Black slate	85	898
	Lime, shale	25	923
	Sand, show of oil 10 feet from top	55	978
	Black shale	150	1128
	Sand, show of oil 5 feet from top	85	1213
	Broken lime	30	1243
	Black slate	225	1468
	Sand, gas and show of oil 10 feet from top	90	1558
	Slate and shale	15	1573
	Black slate	138	1711
	Sand, good show of gas 90 feet from top	225	1936
	Black slate	40	1970
	Sand, show of gas in bottom	50	2020
	Black slate	20	2040
	Sand	10	2050
	Black shale	35	2085
Millstone Grit	Sandstone, large amount of salt water 145 feet from top, and 4-foot coal seam at 2250 feet	265	2350
	Limey shale	10	2360
	Sandstone	184	2544
	Salt water at 2475 feet and 2530 feet.		
Mountain Limestone (Bangor)	Limestone, rotten	160	2704
	Red Rock (limestone?)	50	2754
	Limestone to bottom of the hole	178	2932
	Supposed to be on top of the Hartselle sandstone when the tools were lost and the hole abandoned.		

In the southern part of the county in Sipsey swamp near Newtonville two wildcat wells were drilled by the Five Rivers Oil Company, but no shows of importance were encountered.

During the present winter (1919-20) further geological examination of the southeastern part of Fayette County and the northern part of Tuscaloosa County has been carried on by one of the larger oil companies (Sinclair Oil and Refining Company) as a result of which two holes will be drilled in the vicinity of Berry.

FRANKLIN COUNTY.

GEOLOGY.

The covering of Lafayette and Tuscaloosa gravels, sands, and clays extends over the entire county, especially in the upland interstream areas. Underlying these sediments unconformably the Carboniferous formations are exposed in the valleys (Fig. 18). In the southern part of the county, extending as far north as Isbell and Bel Green the Coal Measures are found underlying the Tuscaloosa. No definite scarp separates this belt from the Sub-carboniferous formations as is the case farther east, but the country is very

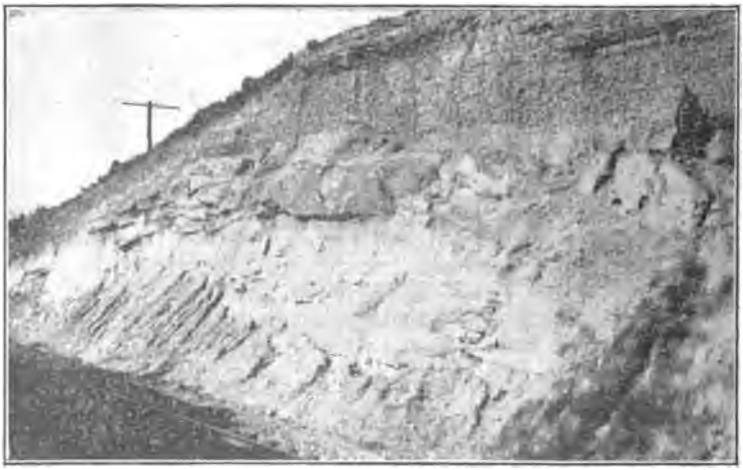

FIG. 18. A cut on the Illinois Central R. R., 4 miles east of Hackleburg, Marion County, showing the Lafayette and Tuscaloosa gravels lying unconformably upon the eroded surface of the Coal Measures. (Photo by R. M. Harper.)

rugged; the streams developing gorges in the lower sandstones of the Coal Measures. From Bel Green northward the Mountain limestone group is exposed in the valleys, and along Cedar Creek and in the northeastern corner of the county the Hartselle sandstone phase appears, breaking off as a north-facing scarp (Little Mountain) in Colbert County.

STRUCTURE.

The fact that throughout the greater part of Franklin County the Carboniferous formations are overlain and concealed by younger formations prevents the accurate determination of the structure of these underlying formations. Enough can be seen, however, to make it evident that these sediments have been gently folded in many places in the county. In the area where the Bangor limestone and Hartselle sandstone outcrop these folds are much more evident and are seen to be generally aligned northwest-southeast. One of the most pronounced of these undulations or waves is located just west of Frankfort on the northern line of the county. At a high point on the axis of this fold a well is now being drilled.

No coal samples have been obtained from Franklin County, but as indicated by the isovolve map, (Fig. 15) the degree of metamorphism is low and the possibility of oil accumulation is as good as in any other portion of northern Alabama. In the southern part of the county the Hartselle might prove a pay sand and to the north the Tuscumbia and Trenton should be reached at less than 1,500 feet.

DEVELOPMENT.

In 1911 the Woodward Oil and Gas Company sank a hole six miles southeast of Russellville.

Woodward Oil and Gas Company, Well No. 1.

SUMMARY RECORD.

Formation	*Character of Material*	*Thickness*	*Depth*
Bangor	Limestone, oolitic, white	288	288
	Shale, calcareous, gray	42	330
	Limestone, white	40	370
	Shale, dark gray	62	432
Hartselle	Sandstone, fine, calcareous	164	596
	Shale, calcareous, gray	134	730
	Limestone, compact, gray	20	750
	Sandstone, coarse, calcareous	10	760
Tuscumbia	Limestone, cherty in part	147	907
Lauderdale	Chert and limestone	308	1215
Devonian	Shale, calcareous, brownish black	25	1240
Clinton	Shale, calcareous, red and green	140	1380
	Limestone, greenish white	20	1400
Trenton	Shale, calcareous, black	215	1615
	Limestone, brown to white	150	1765
	Sandstone, fine, calcareous	50	1815
	Limestone, white to gray and brown	475	2290
Knox	Dolomite, light gray, granular, oily	270	2560

WATER.

First water (fresh) at 265 feet.
Second water (brackish) at 475 feet.
Third water (salt) at 2295 feet.

The salt water continued to the bottom of the hole, with a notable increase at 2330 feet.

GAS.

A small but persistent flow of gas was encountered at 1645 feet, in the Trenton limestone.

OIL.

Traces of oil and the odor of oil were noted from 1750 to 1830 feet, in the Trenton sandstone and limestone; and the odor of oil was very marked in the Knox dolomite from 2295 feet to the bottom of the hole. No oil or gas was noted in the Hartselle sandstone.

In 1917 a test was begun on the Moss farm near Atwood with cable tools and completed to the depth of 2,609 feet with a diamond drill. This well was not located upon any favorable structure, and considering the promising shows that were encountered it should recommend rather than condemn the territory.

Log of Test Hole Sunk On J. L. Moss Farm, Atwood, Alabama, Section 26, Township 8, Range 14, Franklin County.

(Cable Tools to 1,820 Feet.)

	Formation	*Ft. Thick*	*Depth*
PENNSYLVANIAN	Soil	10	10
	Gumbo (black fire clay)	20	30
	Sandstone shell, hard	3	33
	Gumbo, black and soft	32	65
	Slatey sandstone	10	75
	Gumbo, black	13	88
	Sandstone, light	4	92
	Blue fire clay	3	95
	Green sandstone	25	120
	Dark shale	12	132
MISSISSIPPIAN	Limestone	4	136
	Red rock, soft	10	146
	Limestone	27	173
	Sandy limestone	13	186
	Red rock, soft	5	191
	Sandy limestone	88	279
	Slate, soft	2	281
	Red rock, soft	10	291
	Limestone, light, pure	61	352
	Slate	2	354
	Limestone	16	370
	Slate	2	372
	Sandy limestone	15	387
MISSISSIPPIAN Bangor Limestone	Limestone	77	464
	Limestone, very hard	50	514
	Sandy limestone, hard	52	566
	Slate, soft (some salt water)	18	584
	Sandstone	7	591
	Limy slate	53	644
	Limestone	2	646
	Soft slate	3	649
	Limestone	11	660
	Soft slate	1	661
	Limestone	9	670
	Sandy limestone	20	690
	Limy slate	80	770
MISSISSIPPIAN Hartselle	Sandstone	38	808
	Asphalt 775-808—Limy sandstone	37	845
	Slate	1	846
	Limy sandstone with trace of asphalt	26	872
	Sandy limestone	49	921
	Sandstone (shows lime)	10	931
	Sandy limestone	29	960
	Pure slate	58	1018
	Limestone shell	2	1020
	Limy slate	62	1082
	Limestone	25	1107
	Limy sandstone	13	1120

	Formation	*Ft. Thick*	*Depth*
Tuscumbia	Limy slate	4	1124
	Sandy limestone (show of gas)	4	1128
	Limestone	12	1140
	Sandstone (show of oil)	3	1143
	Limestone, very hard	109	1252
	Limy sandstone	16	1268
	Dark limestone (show of oil)	4	1272
	Limy sandstone	16	1288
Lauderdale	Sandy limestone, very hard	80	1368
	Coarse gray limestone	9	1377
	Dark shale, some lime	24	1401
	Sandy lime, very hard	42	1443
	Limestone	75	1518
Devonian	Light, limy sandstone	12	1530
	Limestone, very hard	70	1600
SILURIAN Clinton	Slaty lime, soft	8	1608
	Slaty lime, hard streaks	131	1739
	Slate, soft, limy	23	1762
	Hard limestone	11	1773
	Red rock, limy	38	1812
	Red rock, blood red changing to lighter at bottom of hole	8	1820

DIAMOND DRILL CONTINUATION.

(In the main by W. J. Douglass.)

SILURIAN Clinton		1820–1825	Very white crystalline limestone. (Would make a very pretty marble.)
		1825–1841	Green and black shales.
	35 ft.	1841–1855	Dary gray sandy limestone.
		1855–1876	Dark gray sandy limestone.
		1876–1896	Dark limy shale. Contains sand and is almost entirely lacking in slaty structure.
		1896–1913	Shaly, sandy limestone. Pyritiferous or chalcopyritiferous in last 2 feet.
		1913–1927	Shaly, sandy limestone. Pyritiferous or chalcopyritiferous in last 2 feet.
		1927–1937	Shaly formation. Conglomeratic in appearance.
		1937–1957	Alternate shale and limestone.
		1957–1977	Alternate shale and limestone.
		1977–2016	Shale. Pyritiferous in places. Last 4 feet crystalline limestone with (2012) indication of oil.
	21 ft.	2016–2026	Limestone crystalline.
		2026–2037	Limestone, dense.
		2037–2052	Limestone, denser, with thin slate beds.
	85 ft.	2052–2073	Crystalline limestone, massive in places.
		2073–2106	Continuation of above.
		2106–2127	Continuation of above.
		2127–2137	Continuation of above, with thin, irregular beds of shale.
		2137–2163	Continuation of above.

ORDOVICIAN Trenton	73 ft.	2163–2240	Continuation of above. Limestone varies from white to brown and crystalline to semi-crystalline.
	31 ft.	2240–2271	Dark gray limestone, massive.
	13 ft.	2271–2284	Dark gray limestone, massive, hard.
	26 ft.	2284–2298	Semi-crystalline limestone.
		2298–2310	Dense, hard limestone. Dark gray.
		2310–2318	Dense, hard limestone, with occasional thin beds of shale.
		2318–2331	Dense, hard limestone with occasional thin beds of shale.
	20 ft.	2331–2351	Hard, white, dense limestone. Cuttings show a thin black formation.
	116 ft.	2351-2370	Dense limestone, white (greenish blue).
		2370–2446	Dense limestone, white (greenish blue).
		2446–2467	Dense limestone, white (greenish blue).
		2467–2588	Dolomitic formation. Fine grained.
		2588–2609	White dolomitic formation. Strong ooze of oil for over 5 feet.

NOTE.—By S. A. Hobson: At 2423 grew cherty with occasional vertical splits in core. At 2446 grew seemingly dolomitic, core rather uniform in structure, finely crystalline, of lighter color.

Either Knox or Lower Trenton	Buff dolomite containing oil struck at 2588. Gas, probably 2 first feet. Buff dolomite 2588-2609. Only went 21 feet in this great sand. A heavy shot would probably pay in this 21 feet without going further even.

Oil sand a dolomitic limestone, beautiful yellow, as the core came out; leached rapidly to white from evaporation. Oil extra fine quality, very clear except for yellow tinge. Gas: rock pressure probably 1,000 lbs. though open flow small, from tightness of the sand.

Encouraged by the shows that were struck in the Atwood well another hole was started by S. A. Hobson on a well-defined structure near Frankfort. The test started in on the Hartselle sandstone with the Knox dolomite as the final objective, but it was hoped that production would be found at higher horizons. The results of this test have not been encouraging. Small shows of oil were found in both the Tuscumbia and the Trenton, but the top of the Knox has now been reached and though gas may be found the chance for oil in paying quantities is remote. The following is the log of the Frankfort well down to 1,765 feet. At the present writing (March, 1920) drilling has been continued in the Knox to about 2,000 feet with negative results.

Log of Frankfort Well, Drilled by United Oil Company in N.E. Corner of N.W. ¼, S. 7, T. 6, R. 12.

Begun about middle of September, 1918.

		Ft. Thick	*Depth*
HARTSELLE SANDSTONE	First stroke of drill in Hartselle sandstone (the thick massive upper sandstone of the Hartselle formation). Massive, fine-grained silicious sandstone, with occasional somewhat limy streaks	150	150
	(Note—Small quantity fresh water 20-50 feet. from 75-90 feet very rich saturation of heavy, dead oil, none of which would flow into hole.)		
	Limy shale	85	235
	Massive, slightly sandy limestone	15	250
	(Note—Set 8-inch casing at 253.)		
	Shales with occasional ledges of limestone	25	275
	Limy sandstone, black, with *rich saturation of dead, black oil*	6	281
	Irregular alterations of gummy shales and more or less sandy limestones	69	350
	Massive sandy limestone	25	375
Lower Bangor	Irregular alterations of vari-colored amorphous cavy shales (in places highly fossiliferous) and limy sandstone ledges; latter saturated with dead oil	22	397
	(Note—Caves compelled resetting of 8-in. at about 407.)		
	Gray limestone	3	400
Tuscumbia Limestone	Lighter colored limestone	62	462
	(Note—Sprightly gas at 400, stronger at 413, small additional oozes at sporadic intervals all along to 465—about enough, in aggregate, when burned in boiler over night to show 20 pounds of steam next morning.)		
	Massive gray to white limestone with occasional cherty inclusions (about)	113	575
	Whitish, slightly sandy limestone, showing, between 575 and 580 feet, about 1/3 of a boiler per hour of slightly salt water	15	590
Lauderdale Chert	Gray to white limestones, intercalated with layers or stringers of chert, occasionally showing inclusions of black, dead oil residue, viscous and sticky as chewing gum	45	635
	Sandy limestone with many cherty interspersements	53	688
	Very dark limestone with many cherty interspersements and shaly intercalations	64	752
	(Note—Strong flow of salt water at bottom of last item; unable to get cuttings of last few screws; 6¼-inch casing set at 760-8 feet.)		
	Hard, cherty limestone	18	770
Devonian	Black shale	14	784

			Ft. Thick	Depth
SILURIAN	Niagara	Slightly sandy white limestone; so white slush looked like stream of clabber	65	849
		(Note—A little salt water at 790.)		
		Greenish to grayish shales	68	917
	Clinton	Sandy limestone with reddish, highly ferruginous argillaceous inclusions	10	927
		Same, growing more ferruginous	18	945
		Hematitic limestone, with apparently little or no silica	30	975
		Same, with slightly less iron	23	998
	Trenton Limestone	Gray shale; limy; with some hard ledges	132	1130
		Hard sandy limestone with slight gas odor	20	1150
		Shaly limestone with sporadic 1-2 ft. hard ledges	85	1235
		Limestone making pinkish-brown slush with slight gas odor	175	1410
		White limestone	53	1463
		Darker limestone	87	1550
		Hard cherty ledge	3	1553
		Limestone	7	1560
		Dark colored limestone, slightly softer, with strongly oil-smelling slush	25	1585
		White limestone	30	1615
		Hard ledge	8	1623
		Irregular alterations of variable thicknesses (2-10 feet) hard and soft limestone	47	1670
		Hard cherty limestone	12	1682
		Softer limestone	12	1694
		Very hard limestone, dark to light colored	71	1765
	Knox dolomite	Light colored limestone (probably dolomitic) with slight gas right at the top.		

JACKSON COUNTY.

GEOLOGY.

Jackson County is readily divided into the southeastern area of Coal Measures, a portion of Sand or Raccoon Mountain; the central Sequatchee Valley, occupied by the Tennessee, along which all the Paleozoic formations down to and including the Knox are exposed; and the northwest half of the county, where the Coal Measures are again exposed in isolated plateaus, except along the stream courses where they have been removed by erosion, and the limestones of the Sub-carboniferous exposed.

STRUCTURE.

The principal structural feature of Jackson County is the Sequatchee anticline, an asymmetrical fold of the Ap-

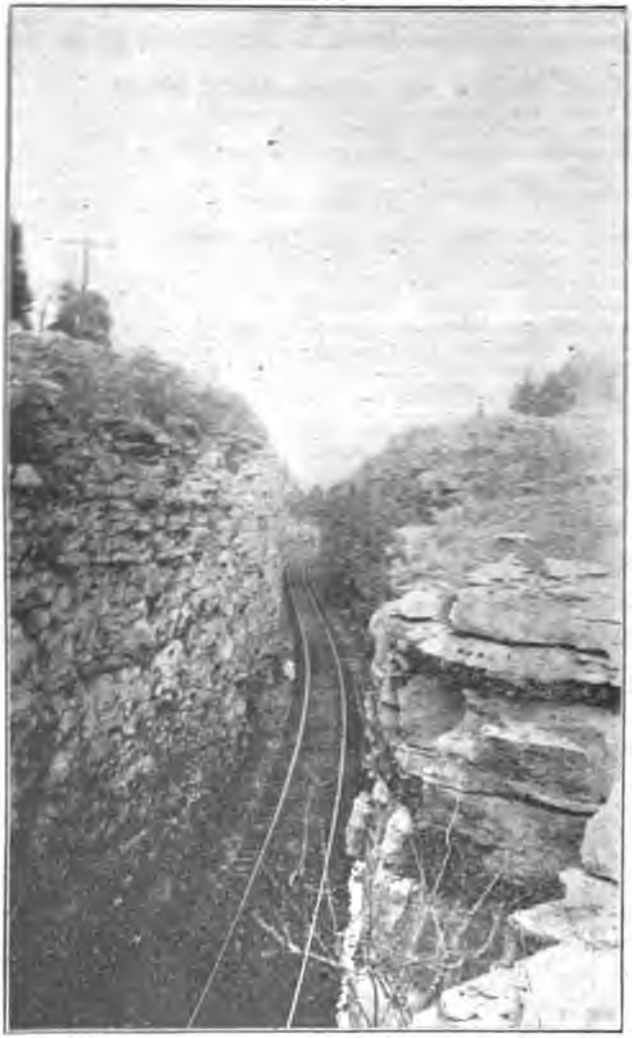

FIG. 17. A cut in the Bangor limestone near Lim Rock, Jackson County. In adjacent counties this limestone occasionally shows extensive oil saturation. (Photo by R. M. Harper.)

palachian type showing a steeply inclined northwest flank, which is locally faulted. Along the axis of this fold the Knox dolomite is exposed throughout the entire length of the valley, so the anticline is of no value as an oil or gas trap. To the southeast on Sand Mountain the Coal Measures occur in a broad gentle syncline. Minor anticlines or domes in this area might be worth testing for gas, but oil could not be expected. In the Carboniferous area northwest of the Sequatchee Valley similar structures can be located, but it must be remembered that this area lies in the general synclinal region between the main Appalachian Uplift and the Cincinnati-Nashville Arch. Moreover the degree of metamorphism is rather high so that a test in this region could hardly be expected to produce anything more than gas from the Trenton or Knox (Sections 1-3, Plate II.)

DEVELOPMENT.

In 1913 a well was drilled near Bridgeport, but encountering the Knox dolomite at a comparatively shallow depth, the well was abandoned at about 500 feet.

During the same year a well was drilled in the vicinity of a gas seep about two miles north and a little east of Stevenson, at a point near the base of the Bangor limestone. A show of gas was encountered at about 900 feet in the Clinton. Drilling was continued to 1,700 feet in depth, or about the base of the Trenton, with no other shows of importance.

JEFFERSON COUNTY.

GEOLOGY.

In Jefferson County the entire Paleozoic series with the exception of the Weisner quartzite is represented, showing an aggregate maximum thickness of 12,000 feet. The county can be divided into four distinct divisions: First, the Cahaba Valley, a portion of which extends into the southeastern end of the county. This is an anticlinal valley of the Appalachian type and along its floor are exposed the Ordovician and Cambrian strata, including the Coosa shales. Secondly, the Cahaba coal field proper, an upland plateau area of approximately 100 square miles in extent in this county, in which the Coal Measures show a maximum thickness of over 5,000 feet. Thirdly, the Jones or Birmingham

Valley district, traversing the county from northeast to southwest, in which, like the Cahaba Valley, the series as far down as the Knox dolomite is exposed, and fourthly the Warrior coal field covering over half of the county, an area of some 600 square miles, in which the Coal Measures are developed in maximum thickness of over 4,000 feet. This last area is by far the most important of the county from the point of view of oil or gas production.

STRUCTURE.

Jefferson County lies wholly in the region of the folded Appalachians and its general structure can be summarized as three sharp parallel Appalachian folds including two much gentler synclinal areas. These anticlines are all of the Appalachian type showing steep northwestern limbs, more frequently faulted than otherwise, and the normal northeast alignment. The southernmost of the three, the Cahaba Valley, is separated from the Cahaba coal field on the north by a thrust fault showing much over three (possibly ten) thousand feet of stratigraphical displacement, the Montevallo shales being brought into juxtaposition with the beds of the Coal Measures. The Cahaba coal field is generally synclinal, being abruptly terminated to the south of this fault. The Birmingham anticline is complex, showing several minor wrinkles whose axes are marked by thrust faults of considerable displacement. This is especially the case in its northeast extension in the northeast corner of the county, where the valley broadens out to eight or ten miles and four or five distinct anticlinal axes can be recognized in crossing it. (Sections 16-23, Plate II.)

The Warrior coal field, like the Cahaba, is bounded on the south by a fault. The general structure of the Warrior field is synclinal, but in the northern part of the county the basin is broken by the southward continuation of the Sequatchee or Brown's Valley anticline, which in this area is a gentle fold with a maximum inclination on the northern limb of 30 degrees. The higher beds of the Coal Measures cover this fold as it pitches rapidly to the southwest. In the syncline between this anticline and the Birmingham Valley the Coal Measures are developed in great thickness and it is in this area that many of the largest coal mines of the State are located.

As the Cahaba Valley and the Birmingham Valley anticlines can be eliminated there remain the Cahaba and Warrior basins and the Brown's Valley anticline where oil or gas accumulation could be possible. An examination of the map showing the fixed carbon ratios of northern Alabama (Fig. 15) shows that throughout the whole county the percentage of fixed carbon is so high that oil accumulation in large quantities would be extremely improbable. For this reason the writer does not believe that any part of Jefferson County is favorable oil territory, but the possibilities for gas in commercial quantities are good, and it is not at all unlikely that valuable gas pools will be developed in the county.

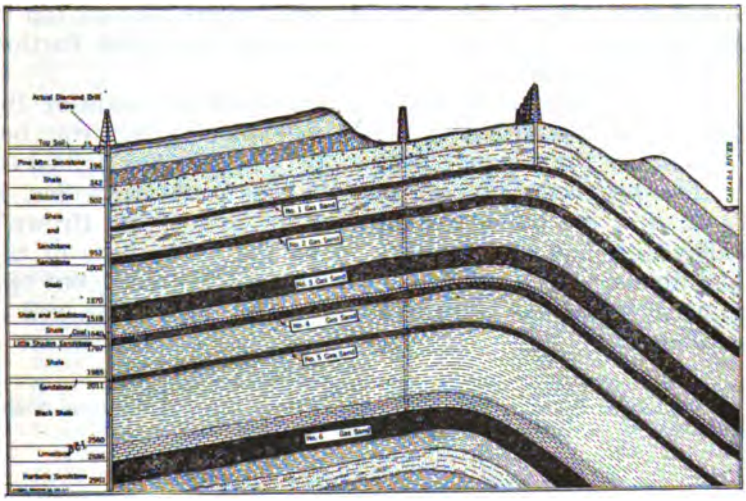

FIG. 19. A generalized section of the Aldrich Dome, Jefferson County, based upon the core of the diamond drill hole in its vicinity. The sands represented are possible gas horizons but only the first has yet proved productive. (Courtesy of T. H. Aldrich, Jr.)

DEVELOPMENT.

The possible gas territory is therefore the Cahaba and Warrior coal fields and the Brown's Valley anticline. South of Birmingham on the northern outskirts of the Cahaba basin several anticlines and domes have been located in the Coal Measures; some of these have been mapped in detail by the U. S. Geological Survey,* and it is evident that they are true domes and should make excellent gas traps. One of them, Dolly Ridge or Aldrich Dome, has already proved productive in a small way. This dome extends from Sec. 27, T. 18, R. 2 W. to Sec. 12, T. 19, R. 3 W., and has been tested by five shallow wells ranging in depth from 165 to 225 feet. Three of these have proved productive, their capacity being roughly estimated at 75,000 to 1000,000 cubic feet a day (Fig. 19). A deep test to the Hartselle sandstone was started by the Dixie Gas Company, but at 2,300 feet the tools were lost and the hole abandoned. Later it was continued by diamond drill to 2,523 feet, where just on top of the Hartselle sandstone the rods were lost and further progress abandoned.

Several wells have been drilled along the axis of the Brown's Valley anticline, chiefly in exploring for iron, but incidentally for oil and gas. In 1911 a well was drilled on the line between Jefferson and Walker Counties in Sec. 1, T. 15, R. 5 W., being located near the axis of the Brown's Valley anticline and starting in on the lower beds of the Coal Measures. No shows of oil were encountered, but two small shows of gas were reported. The log of this well is as follows:

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* Charles Butts: The Northern Part of the Cahaba Coal Field, Alabama, U. S. Geol. Survey, Bulletin 316, pp. 76-115. 1907.

Final Record of Test Well No. 2, Located in the Center of Section 1, Township 15, South of Range 5 West. Elevation 484 Feet.

Started February 12, 1911. Completed May 5, 1911.
Record by John A. Udden.

	Thickness	*Depth*
Recent:		
Surface soil	4	4
Pennsylvanian—Coal Measures:		
Brown sandstone, weathered	15	19
Gray sandstone with occasional shales	58	77
Sandy shale	10	87
Sandstone, very fine-grained, hard, light gray colored	78	165
Black colored shale	95	260
Gray colored sand	28	288
Fresh water came up within 110 feet of surface.		
Sandy shale	8	296
Light gray sandstone	392	688
At about 650 feet another water horizon was struck.		
Mississippian-Sub-carboniferous:		
Bangor formation—		
Grayish limestones and shales	67	755
Grayish colored limestone	402	1157
With show of gas at 1148 feet.		
Grayish colored limestone with some black shale	20	1177
Hartselle formation—		
Dark colored, medium-grained sandstone in which there was water	18	1195
Dark gray shale	26	1221
Medium to fine-grained, brownish colored sandstone, slightly calcareous	9	1230
Tuscumbia formation—		
Dark shaly limestone containing varying amounts of siliceous matter	179	1409
Dark gray shaly limestone, show of gas, flow of salt water	4	1413
Grayish colored limestone in which there was some siliceous matter	67	1480

Farther southwest along the axis of this anticline a deeper well was drilled by the same company (Tennessee Coal, Iron & Railroad Company) to the depth of 3,130 feet. This well is located in Sec. 27, T. 15, R. 5 W., and penetrated almost through the Trenton limestone. Some very encouraging shows were found.

Log of Well No. 1, Northeast of Bryan, Alabama, Section 27, Township 15 South, Range 5 West.

		DEPTH	
		Top	*Bottom*
COAL MEASURES Millstone Grit	Surface soil	0	6
	Sandstone	6	70
	Shale with interbedded sandstones	70	220
	Sandstone	220	465
	Shale, dark	465	500
	Sandstone, with thin shaly layers	500	855
	Gas show at 595 feet.		
	Shale, dark, carbonaceous	855	870
	Sandstone, coarse-grained, conglomeratic, with some shaly streaks	870	960
Bangor	Limestone, dense, massive, bluish color. Occasional shaly layers	960	1500
Hartselle	Sandstone, brown, coarse-grained	1500	1630
	Gas show at top of sand.		
	Shale, dark calcareous	1630	1700
Tuscumbia	Limestone, dark cherty	1700	1955
Lauderdale	Chert, very hard, pinkish	1955	1970
Devonian	Shale, black	1970	1975
	Limestone	1975	1995
	Limestone, sandy	1995	2025
	Limestone, ferruginous	2025	2055
	Sandstone, brown	2055	2065
	Limestone	2065	2075
SILURIAN Clinton	Sandstone, brown, grading into ferruginous sandstones of the Clinton	2075	2345
	Shale, reddish	2345	2365
	Sandstone, brown	2365	2400
ORDOVICIAN Trenton	Limestone, massive, gray to dark blue in color, with occasional shaly and sandy horizons	2400	3130
	Small show of oil in fine-grained limestone, good for one-half barrel a week, at about 3100 feet. The well was shot June 20, 1911. At first no oil showed but later about the same amount as before the shot.		

Still farther southwest along this axis the Pratt Consolidated Coal Company is making two deep tests; the first of these, located near Flat Creek in Sec. 19, T. 16, R. 5 W., has been completed to the depth of 3,087 feet, getting numerous shows of oil and gas and a large amount of gas at 1,231 feet. A very careful log has been made of this well, which is given below:

Record of Test Well No. 1, at Flat Creek, Alabama.

Location: Northeast quarter of northwest quarter, Section 19, Township 16 South of Range 5 West, at Flat Creek, Alabama.

Started: May 28, 1916.

Completed: October 27, 1917.

Elevation: 412 feet.

Churn Drill hole to 2262 feet. Diamond Drill hole, 1⅛-foot core, below.

Drilled for Pratt Consolidated Coal Company.

Record of Diamond drilling by C. S. Blair.

		Thickness		*Depth*	
		Ft.	In.	Ft.	In.
COAL MEASURES	Surface	8	....	8	....
	Coal: *Jagger (?) Seam*	1	....	9	....
	Fireclay and soft slate	8	....	17	....
	Sandstone gray	21	....	38	....
	Slate, dark	32	....	70	....
	Hard shell lime	6	....	76	....
	Slate	40	....	116	....
	Sandy slate, hard	10	....	135	....
	Slate and sandy shell	35	....	170	....
	Sandstone, gray and hard	20	....	190	....
	Slate, dark and colored	13	....	203	....
	Coal: *Black Creek Seam*	1	....	204	....
	Sandstone with oily smell	36	....	240	....
	Slate with hard streaks, light colored	120	....	360	....
	Very hard sandstone with hard streaky slate	155	....	515	....
	Sandstone, dark gray, very hard, show of gas at 548	68	....	583	....
	Slate and lime shells	40	....	623	....
	Sandy shell, very hard	17	....	640	....
	Slate, soft; some lime	65	....	705	....
	Sandy shell, smell of oil	4	....	709	....
	Lime, slate, hard	28	....	737	....
	Sandstone, very hard, gray	38	....	775	....
	Sandy slate, soft	10	....	785	....
	Hard gray sandstone, show of gas at 794	154	....	939	....
	Slate	86	....	1025	....
Millstone Grit	Hard sandstone	211	....	1236	....
	(Note—Some water at 1200 feet, with show oil coating tools at 1215 feet. Large amount water at 1222 feet with large amount of gas with enough pressure to come through well full of water at 1231 feet.)				
	White open sandstone (gas with show of oil in top 4 inches)	74	....	1310	....
	Slate	10	....	1320	....
	No record	80	....	....	....
	Hard sandstone at base of the Coal Measures	150	....	1550	....

		Thickness		Depth	
		Ft.	In.	Ft.	In.
MISSISSIPPIAN	Shale	34	—	1584	—
	Limestone (Bangor)	376	—	1960	—
	No record	45	—	2005	—
	Hartselle sandstone, fine-grained, brown sandstone	120	—	2125	—
	No record	137	—	2262	—
	Dark colored limestone with black shale partings; mostly fine-grained (Tuscumbia)	309	—	2571	—
	Limestone and chert, chert seams to 8 feet thick	10	—	2581	—
	Limestone, coarse crystalline, white to pink colored with green shale and ferruginous partings (Lauderdale chert)	126	—	2707	—
DEVONIAN	Hard brown sandy shale, green in places	6	—	2713	—
	Pinkish, coarse, crystalline limestone	6	—	2719	—
	Greenish shale, limestone seams	18	—	2737	—
	Brown hard limy shale and shaly limestone	30	—	2767	—
	Fine-grained brown shaly sandstone	8	—	2775	—
	Green shale	15	—	2790	—
	Fine-grained brown shaly sandstone	8	—	2798	—
CLINTON	Ferruginous sandstone, lean ore	0	6	2798	6
	Fine-grained brown shaly sandstone, green shale partings	30	6	2829	—
	Green shale, 2 feet lean ore at top	4	6	2833	6
	Lean ore	0	3	2833	9
	Green shale	1	3	2835	—
	Gray sandstone, fine-grained	1	5	2836	5
	Lean ore	6	8	2843	1
	Sandstone, fine-grained, lime streaks	10	11	2854	—
	Sandstone, fine-grained, shale partings	16	—	2870	—
	Green shale	6	3	2876	3
	Lean ore, mottled with white lime fossils	0	3	2876	6
	Green sandy shale	2	0	2878	6
	Lean sandy ore	0	6	2879	—
	Shale	1	3	2880	3
	Lean ore	0	3	2880	6
	Sandstone, fine-grained	16	6	2897	—
	Mottled brown shale interbedded with coarse crystalline limestone in about equal amounts	25	—	2922	—
	Iron ore	2	8	2924	8
	Coarse pink crystalline limestone with ore interbedded shaly in places, ore about 50% rock	20	4	2945	—
	Fine grained shaly sandstone green shale interbedded	50	4	2995	4
	Ore, good fine-grained (one piece analyzed ran 43.20 in iron)	7	2	3002	6
	Green shale	0	1	3002	7
	Ore	0	1	3002	8
	Shale	0	4	3003	—
TRENTON	White limestone, shale partings	1	8	3004	8
	Black shale	1	—	3005	8
	Shaly limestone, black shale interbedded, shale decreasing in depth	130	—	3135	—

The second well now drilling near Praco at 3,200 feet is being drilled with a diamond drill and the core has been carefully preserved. It started in at a point about a hundred feet stratigraphically higher than the well at Flat Creek. In other respects the two logs correspond closely. Mr. S. A. Hobson has carefully examined and described the core to the depth of 3,150 feet, and the following log is based upon his observations:

Praco Diamond Drill Hole, Near N.E. Corner Section 36, Township 16 South, Range 6 West.

Starting a few feet below the level of the Mary Lee Coal Seam.

			Thickness	*Depth*
COAL MEASURES		Shales and arenaceous shales	120	120
		Sandstone, tight, fine-grained	30	150
		Shales and sandy shales	60	210
		Sandstone, medium to coarse-grained with a few shaly layers	35	245
	Fayette Sand, Upper & Lower Conglomerates	Coal seam of undetermined thickness, probably Black Creek seam.		
		Shaly sandstone and alternating shales and sandstones	360	605
		Sandstone, fine-grained micaceous	20	625
		Shales and sandstones alternating	525	1150
		Sandstone, massive with occasional thin shaly layers. A few small pebbles near bottom	535	1685
		Conglomerate, massive throughout without a break	30	1715
		Oil saturation in places from 1680-1715 feet.		
		Shales, with occasional thin conglomerates	100	1815
		Sandy shale or lime	20	1835
		Shales, thin-bedded, fine-grained	64	1909
MOUNTAIN MILLSTONES	Bangor	Limestone, dense, bluish, locally arenaceous or argillaceous	296	2205
		Shale, calcareous, with thin limestone and sandstone horizons	20	....
	Hartselle	Sandstone, fine-grained, with occasional shaly horizons	107	2313
		Oil saturation at irregular intervals.		
		Shales growing calcareous towards base	161	2474
		Marly limestone	11	2485
Tuscumbia		Limestone, massive, slightly shaly towards top	95	2580
		Oil saturation at frequent intervals.		
		Gas sand 2498-2505, very porous, composed of shell fragments.		

			Thickness	*Depth*
	Lauder-dale	Chert and cherty limestone	165	2745
Devo-nian		Shales, dark, calcareous	87	2832
SILURIAN	Niag-ara	Limestone, massive	14	——
		Limestone, massive, highly ferruginous	20	——
	Clinton	Shales, ferruginous	20	——
		Shales, varicolored, calcareous layers	109	3000
		Shales, ferruginous	5	3005
		Sandstone, shaly, slightly ferruginous in places	145	3150
		Bottom of hole, March 1, 1920	—	3350

While the wells that have just been described have been located approximately upon the axis of the Brown's Valley anticline, still it has been noted that this fold pitches rapidly to the southwest along this portion of the axis. Considering the favorable gas shows that have appeared in these tests it should certainly be worth while to make a careful survey of the entire length of the fold in Jefferson County to determine if there is any point where the pitch is reversed and a node or dome developed along the crest. Such a point should have very good possibilities as a gas trap. The writer has made only a cursory examination of the region, but from what he has seen he believes that such structures do exist and can be located by careful examination.

LAMAR COUNTY.

GEOLOGY.

The entire surface of Lamar County is covered by the gravels, sands, and clays of the Tuscaloosa and Lafayette formations, except a few square miles along the larger stream courses of the northeastern part of the county, where the underlying Coal Measures are exposed.

STRUCTURE.

The Tuscaloosa formation lies unconformably upon the Coal Measures and shows a general dip to the southwest. Owing to the unconsolidated or partially unconsolidated nature of these sediments exposures are rare and the local structure is difficult to determine. As the two series are separated by an unconformity favorable structures that might occur in the concealed Coal Measures would probably have no reflection at the surface in the Tuscaloosa series, or structure developed in the Tuscaloosa would not continue unchanged down into the Coal Measures. Therefore the geologist is greatly handicapped and production, if developed at all, must be developed by the wildcatter.

A recent analysis of coal from T. 12, R. 14 W., Lamar County shows that the fixed carbon is comparatively low, 58 per cent., which would indicate that the accumulation of high grade oil would not be impossible in the Coal Measures and the underlying horizons.

DEVELOPMENT.

One wildcat test has been made in the county which got such good shows that the promoters of the enterprise were encouraged to continue their efforts in Marion County. This well is known as the Guin well, drilled by Frederick Morck in 1918, just west of the town of Guin in the N.E. 1/4 of S.E. 1/4 of Sec. 25, T. 12, R. 14 W.

Log of Guin Well.

			Thickness	*Depth*
Tuscaloosa		Surface casing	—	138
		Gumbo and running sand	30	168
		Shale and red sand alternating	37	205
		Gumbo and sand	235	440
Fayette sand		White sand	135	575
		Slate	134	709
Upper Conglomerate		Light gray sand	86	775
		Dark sand	330	1105
		Sands alternating in color and porosity	6	1111
		Black sand	7	1118
		Dark gray sand	100	1218
		Black shale	27	1245
		Dark sand	35	1280
Lower Conglomerate or Millstone Grit		Gray sand (fine quality)	20	1300
		Black shale	50	1350
		Black shale continued	25	1375
		Dark sand	75	1450
		Gray slate	5	1455
		Gray slate continued	55	1510
		Red Sand	55	1565
MOUNTAIN LIMESTONE	Upper Bangor	Light colored slate	45	1610
		Slate and lime alternating	64	1674
	Hartselle Group	*Oil sand with oil*	8	1682
		Hard dark lime	9	1691
		Second sand rich in oil	7	1698
		Hard lime shale	4	1702
		Close sugar sand richly saturated with oil	8	1710
		Shale, limestone and shells	34	1744
		Dark oil sand showing oil	6	1750
		Shale, limestone, etc.	40	1790
		Dark limestone	27	1817
		Dark hard limestone	68	1885
		Dark shale	15	1900
		Dark hard lime	25	1925
		Dark shale, soft	75	2000

The oil from this well coming from the 1,682-foot sand is very heavy and black (19° Baume), apparently a residual oil indicating that the well was not located on a structure that would have caused the accumulation of the entire oil content of the sand, but rather at a point where he lighter constituents could readily migrate off, leaving only the heavier constituents as a residual saturation.

LAUDERDALE COUNTY.

GEOLOGY.

The Tuscumbia limestone occurs in Lauderdale County as an irregular strip following the Tennessee River. North of this area the Lauderdale chert forms the surface throughout the entire county, with the exception of several small and irregular patches of Silurian and Trenton limestone. The strata of this formation are highly siliceous and have weathered forming slightly elevated plateaus and areas of rolling topography descending by sharp bluffs to the stream courses. The light siliceous soil of this area, underlain by the more or less cavernous chert, is rather infertile being generally covered with a growth of pine and oak, and is locally termed the Barrens.

STRUCTURE.

Careful mapping of the structure of the Lauderdale chert reveals the fact that it is warped into slight undulations generally aligned northwest-southeast. Where definite closure can be determined such structures should be worth testing for oil in the Trenton or gas in the Trenton or Knox. So far, however, no test has been made upon favorable structure.

Lauderdale County is situated on the top of the Cincinnati-Nashville Arch, and is also removed from the area of Appalachian folding, so the deformation is not such as would prevent the preservation of the oil, and the general structure is favorable for its accumulation. Lauderdale County, therefore, is a promising territory for future development. (Section 14, Plate II.)

DEVELOPMENT.

In 1893 the late Thurston H. Allen drilled two wells in T. 1 S., R. 10 W. The first was located in the N.W. ¼ of the N.E. ¼ of Sec. 22, and was drilled to 2,760 feet, but did not strike anything but faint traces of oil and gas in the Trenton. The second well was drilled in the S.W. ¼, Sec. 33, T. 1 S., R. 10 W., on Keethly Creek, a tributary of Shoal Creek, at an elevation of 586 feet above sea level. This well probably started in the top of the Silurian (Niagara) limestone and was continued to a depth of 1,460 feet. The following is a summary of the log of the well:

	Top	*Bottom*
Surface soil	1	15
Limestone, gray	15	240
Sandstone, calcareous, at places heavily charged with petroleum	240	330
Blue shale, siliceous	330	440
Oil sand, very light white oil	440	444
Limestone, whitish-gray (Trenton)	444	447
Good gas show, 15 pounds pressure.		
Limestone, darker than that in which the oil and gas was found	447	870
Black shale, bituminous	870	905
Sandstone, reddish, limy	905	930
Limestone	930	1460

The bottom of the hole was probably in the upper portion of the Knox dolomite. The well was shot with 72 quarts of nitro-glycerine, which blew out the casing and demolished the derrick. The owner claimed that this well was good for four or five barrels, but after spoiling the hole by shooting, no other tests were made.

The Florence-Sheffield Oil and Gas Company is now drilling a well near Florence, having reached the depth of 800 feet. The same company is also drilling two wells just across the State line at Iron City, Tennessee. One has reached 500 feet in depth and some very encouraging shows have been encountered.

LAWRENCE COUNTY.

GEOLOGY.

The normal dip of the strata in Lawrence County is slightly west of south, so the successive members of the Carboniferous series cross the county in approximately east-west belts, the older formations outcropping to the north. The Coal Measures capping Sand Mountain form a belt about ten miles wide, occupying the southernmost part of the county. At the foot of Sand Mountain the upper portion of the Mountain limestone group (Bangor limestone) reaches the surface and gives rise to a comparatively level belt of limestone topography, extending several miles north of Moulton. Beyond this point the Hartselle phase of the Mountain limestone outcrops, forming a north-facing escarpment (Little Mountain), north of Little Mountain the lower limestones of the Mountain limestone group reach the surface in a narrow belt, and beyond this the Tuscumbia limestone forms the level plains extending to the Tennessee River.

STRUCTURE.

The geological structure of Lawrence County can, throughout the greater part of the county, be accurately determined by close examination. Exposures are scarce in the northern part of the county, in the area underlain by the Tuscumbia limestone, which is a valley-making formation, easily eroded, and covered with a thick mantle of residual soil. In the southern two-thirds of the county numerous folds trending northwest and southeast can be detected and occasionally others parallel to the Appalachian trend can be seen. In the southeastern part of the county along Caps Creek, a tributary of Clifty Creek, both of these sets of undulations can be recognized. Two tar springs occur in the synclinal trough between two of these undulations on the south bank of the creek in the S.W. ¼ of Sec. 26, T. 8, R. 6 W. The Watson wells described below were drilled near these two tar springs. About five miles southeast of Moulton in Sec. 12, T. 7, R. 7 W., the limestones are folded into waves trending northwest-southeast. Well-defined closure could probably be worked out in this area, but as yet no prospecting has been carried on.

Lawrence County lies well up on the Tennessee-Nashville Arch and is removed from the area of high metamorphism, so for both of these reasons it should be a promising territory for prospecting. Moreover, the Trenton horizon has produced oil in small quantities in the southeastern part of the county, and as this horizon should be reached at less than 1,500 feet in almost all parts of the county the cost of prospecting would not be prohibitive. On the whole the writer regards it as one of the favorable areas of the State for future prospecting. (Section 14, Plate II.)

DEVELOPMENT.

The first wells actually drilled for oil in Alabama were the Watson wells, drilled about 1865 by Jonathan Watson, in the vicinity of the oil springs in the southeastern corner of Lawrence County (S.W. ¼ of Sec. 26, T. 8, R. 6 W.). Several wells were drilled by Watson, and it was reported that good shows of oil were encountered in two of them. These wells were comparatively shallow (700-800 feet), probably reaching the top of the Trenton, where the oil shows were found.

In an adjacent township to the Watson wells there were six wells drilled by the Moulton Valley Oil Company, from 1890 to 1892, known as the Goyer wells. The first of these wells, the Goyer No. 1, is located in the northwest corner of the S.W. ¼, S.E. ¼, Sec. 29, T. 7, R. 6 W., and reached the depth of 2,120 feet. This well got an excellent show of light green oil (38.7° Baume) and was estimated at twenty-five barrels a day by Dr. McRae, the geologist in charge. A careful log was made of this well which is as follows:

*Log of Goyer Well No. 1.**

		Feet
36	Soil	10
35	Limestones; Bangor	290
34	Sandstones; *first gas*, in the upper part	35
33	Shales; a dark blue color	110
32	Limestone; of a pearly white, sulfuretted hydrogen gas was struck in this rock at 55 ft. below its top and salt water at 53 ft. from its top; the salt water on evaporation gave a good flavored salt	80
31	Limestone; of a light drab color	320
30	Limestone; impure, coming out as a coarse powder like corn-meal and hence called "corn-meal sand."	28
29	Shales; Devonian, black	32
28	Limestones; shaly	17
27	Limestones; blue	2
26	Shales; sandy and of a mottled (red and white) color	9
25	Limestone; it carries some little oil	422
24	A gritty calcareous sand, likely from an impure limestone	100
23	Limestone; blue	45
22	Limestone; coarse grained, the lower 5 ft. is an oil sand though it carries no oil	9
21	Limestone; coarse grained, impure and siliceous, a good oil sand. *Oil*	20
20	Limestone; blue	261
19	Limestone; white	32
18	Limestone; blue with greenish specks	6
17	Limestone; white or cream colored	6
16	Limestone; blue	63
15	Limestone; bluish with a slight reddish tinge	26
14	Limestone; white	27
13	Limestone; gray with a slight reddish tinge	4
12	Limestone; white	4
11	Limestone; gray with a few reddish specks	3
10	Limestone; of a light gray color	49
9	Limestone; white	5
8	Limestone; of light gray and reddish specks	2
7	Limestone; of a brownish gray color	5
6	Limestone; white	4
5	Limestone; of a grayish color with white and blue specks	7
4	Limestone; with large white specks that resemble pieces of fossils	4
3	A dark grayish powder with blue and white specks; it may be shale	5
2	Limestone; with white and light gray colors with reddish specks	22
1	Limestone; white	3

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* From report on Valley Regions of Alabama, by Henry McCalley, Part I, p. 239, Geological Survey of Alabama (1896).

Of this above log, 35 is in the Bangor limestone, from 34 down into 31 is the Hartselle sandstone group; from 32 to 30 is the Tuscumbia limestone and Lauderdale chert; 29 is the Devonian; and the rest is Trenton.

The first gas was found in the top of the Hartselle sandstone at 302 feet in depth. It burned ten feet high out of the open end of the six-inch casing. The second gas was struck at 500 feet in the base of the Hartselle group. The production from these two gas sands together were estimated at 20,000 cubic feet per day. The first oil was only a trace, but at 1,530 feet the pay sand was struck and the oil rose to the height of two hundred feet in the well. Some eight barrels of oil were pumped out at this time, but soon afterwards the casing began to leak and salt water impaired the well. The well was then shot with 100 quarts of nitroglycerine, which partially demolished the casing and let in a flood of salt water, thereby ruining the well.

The Goyer well No. 2 was drilled about one and a half miles northwest of the Goyer No. 1 in the N.W. ¼ of Sec. 30, T. 7, R. 6 W. It was continued to 1,565 feet, but only got a show of oil. Quoting Dr. McRae, the geologist: "We completed our well No. 2 at 1,565 feet and found no oil. We found the oil sand all right but it yielded no oil." A good show of gas was struck at the top of the Hartselle sandstone at 220 feet.

These wells were not located with any special reference to geological structure, for at that time the relation between structure and oil accumulation was not fully appreciated. The writer has not visited the locality, but it is quite possible that the Goyer No. 1 was located at the crest of one of the northwest-southeast undulations so frequently developed in the county, and in this way the production could be explained. Since the Goyer tests were made no further prospecting for oil has been carried on in the county.

LIMESTONE COUNTY.

GEOLOGY.

In the southern part of Limestone County the Tuscumbia limestone forms the surface, dipping gently to the south. This formation extends from the Tennessee River almost as far north as Athens; from which point northward it has been removed by erosion, and the underlying Lauderdale cherty limestone exposed. The Lauderdale chert forms the surface all the way to the State line, except along the principal stream courses, where erosion has laid bare the upper strata of the Trenton limestone.

STRUCTURE.

Limestone County lies well up on the eastern flank of the Cincinnati-Nashville Arch and consequently its regional structure is favorable. Throughout the entire county the Trenton horizon can be reached at less than 500 feet in depth. The Trenton is considered one of the most favorable horizons for oil and gas in the State, so the chances should be good for oil and gas, especially gas, accumulations throughout the county. However, there are two distinctly unfavorable conditions, first the Trenton is insufficiently covered in much of this area to become an important oil producer, and secondly, the determination of structure is rather difficult, especially in the area underlain by the Tuscumbia limestone. In the northern part of the county where the Lauderdale and Trenton limestones are exposed the outcrops are numerous and the structure can be accurately mapped. In this area there would be the possibility of gas in the Knox dolomite.

DEVELOPMENT.

No wells drilled for oil and gas have been reported from the county. Gas shows have been found in some of the deeper water wells that reached the top of the Trenton.

MADISON COUNTY.

GEOLOGY.

The Coal Measures in Madison County are confined to the high mountains in the eastern part of the county. The sandstones of the Coal Measures cap these mountains and make flat-topped mesas 1,500 to 1,800 feet above the sea, and from 800 to 1,300 feet above the adjacent valleys. Monte Sano, just east of Huntsville, a well known summer resort is on one of these plateaus nearly 1,000 feet above Huntsville. Throughout the rest of the county the Subcarboniferous limestones are exposed, except in the northern and northwestern portions where the Silurian limestone has been uncovered along the stream courses.

STRUCTURE.

The Lower Carboniferous limestones in the southern part of the county lie practically horizontal and favorable structure for oil accumulation is rare. In the northern part of the county folding is apparently more widespread and good structures are to be found. The major structure of the county is that of geosyncline, as it lies between the Appalachian Uplift and the Cincinnati Arch. The area, therefore, would be less favorable than that to the west. (Section 8, Plate II.)

The most favorable horizon for oil and gas production in the county is the Trenton limestone. The Knox is also a possible gas horizon. These two horizons should be reached throughout most of the county at less than 1,500 feet, and the Trenton at less than 500 feet. These formations would more likely produce gas than oil considering their age and their general proximity to the region of deformation. The possibilities for gas throughout the county are good, therefore, if the tests are made on well-defined structures.

DEVELOPMENT.

In 1905 a well was drilled at West Huntsville to the depth of 2,647 feet for T. W. Pratt. The log of this well has been lost, but as it started in on the Tuscumbia limestone it probably reached the base of the Trenton at about 1,200 or 1,400 feet and therefore penetrated about 1,200 feet of the Knox dolomite, which is over two thousand feet thick in this area. The well was not located with reference to structure, but got a large gas show. The Trenton limestone gave a strong odor of petroleum and good gas shows were encountered in the Knox.

About the same time six wells were drilled a mile northeast of Hazel Green, ranging in depth from 190 feet to 1,690 feet. Five of these wells were less than 600 feet in depth and got gas in the Trenton horizon. The two best producers, about 300 feet in depth, are still producing about 50,000 cubic feet a day. The gas from these two wells comes from near the top of the Trenton. The deep test penetrated well into the Knox dolomite, but only a small flow of gas was obtained from this horizon. At New Market a well was drilled for oil some time ago and reached a depth of over 1,000 feet. No shows of consequence were reported.

A well is being drilled at Bell Factory, about ten miles northeast of Huntsville, with cable tools. This well has reached a depth of 300 feet.

MARION COUNTY.

GEOLOGY.

The Tuscaloosa formation covers by far the greater portion of the area of Marion County. All of the upland area is underlain by this series of sand and variegated clays, which lies unconformably above the Paleozoic, and it is only along the stream courses that the Coal Measures outcrop. In the southern part of the county the Coal Measures underlying the Tuscaloosa probably aggregate 1,000 feet in thickness, while on the northern line of the county only 500 feet or less of Coal Measures separate the Tuscaloosa from the Sub-carboniferous limestones. The topography is in many places rugged as the streams in cutting through the Tuscaloosa series developed rather precipitous gorges in the sandstones of the Coal Measures. At the head of these gorges there often occur massive overhanging ledges of sandstone forming what are known as "rock-houses." In some cases undercutting has gone on so far that part of the roof of the "house" back of the ledge has become loosened and fallen in leaving the outer edge as a natural bridge (Fig. 20).

STRUCTURE.

Since the Coal Measures are exposed in only limited areas it is a difficult task to determine the structure with any degree of accuracy. Certain horizons are found over extensive areas, however, and these can be used as keys to the local structure. The two conglomerates, the upper and the lower, can be readily recognized, though it is often impossible to determine whether a particular outcrop represents the top of either of the conglomerates or simply an eroded surface. It is more satisfactory to try to recognize the shale that separates the two conglomerates. This horizon is rather constant and it can be found throughout most of the county. In the area south and east of Hamilton it can be recognized in the stream courses over an extensive area. It is found approximately at the water level in the principal streams from Sec. 18, T. 11, R. 13 W. to Sec. 25, T. 10, R. 14 W., indicating that instead of the normal dip to the southwest that should be expected there is in reality a terrace between the two points mentioned or possibly a reverse dip giving rise to a dome. In other parts of the county smaller structures have been reported, but it is difficult to determine accurately their size and trend. (Section 18, Plate II.)

The fixed carbon in the coal mined near Brilliant, as shown by analyses, is not high (56 per cent. fixed carbon), indicating that this county lies in a territory as favorable for oil accumulation as any part of northern Alabama. Moreover the Hartselle sandstone should be reached at about 800 feet in the central portion of the county, so that a test could be made even to the Trenton, without great expense. The formations do not cave readily and the drillers can count on making considerable hole a day with ordinary luck.

DEVELOPMENT.

Several diamond drill holes have been put down in the county, but none solely for oil. The deepest diamond drill hole is located about three miles northeast of Hamilton in Sec. 25, T. 9, R. 14 W. This hole was drilled in 1917 by the Gulf Producing Company, a Birmingham concern, to the depth of 2,200 feet in prospecting for iron. The drill pierced the Clinton, stopping in the Trenton limestone. Portions of the core smelled strongly of petroleum but no real shows were found. This, however, is not surprising, for the surface indicates that the well is located in a syncline.

Record of the Hamilton Well.

Drilled by the A-M Oil, Gas and Pipe Line Company in the northern part of Section 25, Township 10, Range 14 West, Marion County, Alabama, with diamond drill.

			Thickness	*Depth*
Upper	Conglomerate	Soil	6	6
		Sandstone, coarse, with occasional shaly layers	75	81
		Alternating shales and sandstones	58	139
Lower	Conglomerate	Sandstone, coarse-grained, conglomeratic occasional shaly layers	90	229
		Shales, dark, calcareous layers	151	380
		Coal 2 inches.		
		Shale, with limy and marly layers, and occasional thin sandstone	165	545
MOUNTAIN LIMESTONE	Bangor	Limestone, dense gray crystalline, fossiliferous with interbedded thin shales and green marls. Three oil shows at 593, 670 and 703 feet, the latter a five-foot sandstone saturated with black oil	158	703
		Limestone, very porous, highly fossiliferous, dense crystalline gray, showing oil and gas at numerous horizons. Rather cherty towards the base	443	1146
		Limy and sandy shales, dark	240	1386
	Hartselle	Sandstone, fine-grained, shaly	20	1406
		Sandstone above mentioned gave good show of oil.		
		Shales and interbedded sandstones	63	1469
		Sandstones and calcareous sandstones with good shows of oil and gas	24	1493
Tuscumbia	Lauderdale	Limestones, dark crystalline, cherty, in places, some shaly layers. Frequent oil shows. Grading imperceptibly into hard, dense, gray cherts. (Lauderdale chert)	227	1720
Devonian (?)		Shale, greenish black	18	1738
		Limestones, cherty, thin shale seams	124	1862
Silurian		Greenish marls and shales, with some layers of dense gray limestone, with occasional pinkish and purplish inclusions	249	2111
		Calcareous shales, greenish	12	2123
		Limestone, ferruginous, compact, greenish and pink	37	2160
Clinton		Iron ore, hematite, two feet	2	2162
		Limestone, fine-grained, ferruginous, pink	31	2193
Trenton(?)		Limestone, dense, dark gray, sandy	200	2393

Another test is just being commenced in Marion County a few miles southeast of Hamilton. This well, being drilled by Frederick Morck, is located in the S.W. 1/4 of N.W. 1/4 of Sec. 24, T. 11, R. 14 W., in the area mentioned above where there is good evidence of a terrace or dome. Drilling will be continued to the Tuscumbia and possibly to the Knox horizon. As this is the first well drilled in the northwestern part of the State, located on fair structure, which will test the Hartselle sandstone at a point where it is sufficiently covered to be productive, the writer awaits the results of the test with a good deal of interest.

MARSHALL COUNTY.

GEOLOGY.

The Carboniferous formations form the surface throughout this county, except in Brown's Valley, the southward continuation of the Sequatchee anticline, where the Paleozoic series down to the Knox dolomite is exposed. This valley divides the county into two almost equal areas underlain by Carboniferous formations; the southeastern half, a portion of Sand or Raccoon Mountain, and the northern half, which has been bisected by the Tennessee River on entering Brown's Valley, leaving Gunter's Mountain to the northeast and a similar patch of Coal Measures to the southwest.

STRUCTURE.

The main structural feature of this county is the sharp asymmetrical anticline that is now eroded down to a valley occupied by Brown's Creek and the Tennessee River. South of this anticline lies Sand Mountain, which is a broad synclinal expanse of Coal Measures. The axis of the Brown's Valley or Sequatchee fold pitches very gently to the southwest, but locally it may be horizontal or even show a reverse pitch so that high points or nodes may be developed along the axis. About eight miles southwest of Guntersville in Warrenton Valley there is a detached area of Knox dolomite, which no doubt represents such a node on the major axis, where local doming has brought up this lower formation. The Knox and overlying cherty limestones are very siliceous in this locality and numerous perfectly developed quartz crystals can be found in the soils of the valley floor. Some of these crystals are discolored and on crushing they yield a strong odor of petroleum, and others show liquid inclusions, presumably petroleum. This was regarded as sufficient indication to warrant local parties in drilling for oil, and about 1890 a well was drilled to the depth of 1,000 feet. This well was named the *Wildcat Well,* a very appropriate term, considering that it started in at a horizon in the Knox, far below any known oil-producing horizon. (Sections 7-9, Plate II.)

Local anticlines and domes aligned either parallel or normal to the main Appalachian trend can be traced out in the Coal Measures both north and south of Brown's Valley. The high degree of metamorphism in this region would preclude the possibility of any large amount of oil, but gas pools might be developed by intelligent testing.

DEVELOPMENT.

No tests for oil or gas other than the Wildcat Well have been reported from Marshall County.

MORGAN COUNTY.

GEOLOGY.

Sand Mountain, capped by the lower sandstones of the Coal Measures, extends across the southeastern part of Morgan County. At the foot of this scarp the Bangor limestone outcrops, underlying a broad undulating plain, extending northward from five to fifteen miles. Throughout this area exposures are scarce and it is rather difficult to determine the structure. North of the Bangor outcrop the Hartselle sandstone is exposed, making another north-facing escarpment, which is called Little Mountain. The width of the Hartselle outcrop is variable, sometimes exceeding fifteen miles. North of Little Mountain are the level plains of the Tennessee Valley underlain by the Tuscumbia limestone.

STRUCTURE.

In the area underlain by the Hartselle sandstone, where the details of the structure can be determined it is evident that folding is very abundant. Most of the folds are of the northwest-southeast alignment and sometimes are fairly sharp, showing dips as great as 30 degrees. In the northern and southern part of the county outside of the Hartselle belt the structure is more difficult to determine.

Morgan County is sufficiently removed from the Appalachian center of disturbance to make possible the accumulation of light oil, but it lies in the synclinal area between the Appalachian region and the Cincinnati-Nashville Arch, which must be considered an unfavorable factor.

Throughout the entire area in which the Hartselle sandstone outcrops oil seeps and asphalt and maltha showings are abundant. In many places the sandstone is permeated or even saturated with oil over considerable areas. These seeps indicate that the Hartselle should be a pay sand where occurring under sufficient cover and other favorable conditions, but it must be remembered that seeps in the Hartselle where it outcrops in Morgan County would mean nothing regarding the possibility of oil in the underlying Trenton horizon, which should be the objective for oil prospectors in this county.

DEVELOPMENT.

The numerous oil springs and seeps in the Hartselle sandstone have brought about the drilling of several wells in Morgan County for oil. In the eighties a well was drilled on the outcrop of the Hartselle sandstone about three miles to the southwest of Hartselle.* The depth of the well was not reported, but it was said that a good show of oil was encountered. Near Hartselle numerous oil seeps occur, and in 1887 a well was drilled at the site of Old Hartselle, about one mile north of the present depot on the old grade of the L. & N. R. R. This well was probably located at this point on account of an oil seep in a nearby lime-sink, but it happened to be also on the crest of a well-defined fold, trending N. 25° W. and showing a steeper west flank (30 degree dip). This anticline can be traced northward for some distance in the limestone outcrops that have been quarried to the north of the old town site.

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* Misspelled "Hartsells" by P. O. Dept. for many years past.

*Log of the Old Hartselle Well.**

		Top	*Bottom*
(21)	Surface soil	0	17
(20)	Limestone; fine grained and of a light drab color	17	23
(19)	Shale; calcareous with fossil corals, etc., of a dark drab color	23	111
(18)	Limestones, shales; the limestones are of a light drab color and have in them streaks of blue limestone and of light colored shales	111	147
(17)	Limestone; of a light drab color and white opaque colors with streaks of iron rust, which leave insoluble residue in hydrochloric acid	147	314
(16)	Limestone; of a blue color and with a fracture something like flint	314	402
(15)	Limestone; hard and fine grained and of a bluish brown color	402	439
(14)	Limestone; flaggy in the upper part, with iron rust in places, light color	439	502
(13)	Limestone; fine grained, blue	502	556
(12)	Limestone; light blue color, with iron rust stains	556	629
(11)	Black shales; Devonian	629	646
(10)	Limestone; shaly, light gray color, carrying the *first gas* at 652 ft.	646	662
(9)	Limestone; blue	662	1005
(8)	Limestone; light color with glistening particles in some of it, carrying near its bottom the *second gas*	1005	1094
(7)	Limestone; of a drab color	1094	1228
(6)	Limestone; light color	1228	1266
(5)	Limestone; dark color	1266	1300
(4)	Limestone; drab color	1300	1400
(3)	Limestone; light blue color, *black oil* at bottom	1400	1500
(2)	Limestone; gray color	1500	1689
(1)	Sandstone; calciferous and of a light gray color, to the bottom of the well	1689	1730

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* Adapted with corrections from Report on the Valley Regions of Alabama, by Henry McCalley, Part I, p. 254, Alabama Geological Survey, 1896.

Of the above log (1) is probably the Knox dolomite, (2) to (10) inclusive are the Trenton limestones, (11) is the Devonian black shale, (12) to (16) inclusive are the Lauderdale cherts, (17) is the Tuscumbia limestone, and from (18) to (20) inclusive are the formations of the Hartselle group. The local reports were that both oil and gas were found in this well in small quantities, but not of sufficient quantities to be of commercial value. No subsequent tests have been made in the immediate vicinity of this well.

PICKENS COUNTY.

GEOLOGY.

The Coal Measures, the only possible source of oil in Pickens County, are covered by from 200 to 1,200 feet of Cretaceous strata lying unconformably over them (Fig. 18). This covering effectually conceals all favorable structure that might be developed in the Coal Measures, so any location that might be made would be wholly at random and the chances for production very remote. However, the Coal Measures in this county might well become a productive petroliferous series as the area is sufficiently removed from the center of deformation and metamorphism for oil to accumulate in considerable quantities.

SAINT CLAIR COUNTY.

GEOLOGY AND STRUCTURE.

Saint Clair County, lying in the Coosa Valley region, is roughly bisected by the Coosa coal field. On either side the older Paleozoic formations are exposed, showing sharp folding and widespread faulting. Since these areas can be eliminated, and there only remain the synclinal troughs of the Coosa and the Cahaba coal fields, only the northern tip of the latter extending into the county, where gas accumulation would be possible.

DEVELOPMENT.

Oil seeps have been reported in the Coosa field at Cook's Springs, and some unimportant shows of oil and gas have been encountered in making tests for coal and iron, but considering the unfavorable structure and rather intense deformation there is nothing to warrant the expenditure of considerable sums in making tests solely for oil and gas.

SHELBY COUNTY.

GEOLOGY AND STRUCTURE.

The Carboniferous formations underlie the greater part of Shelby County. The structure of this area is generally synclinal, though a rather pronounced faulted anticline bisects the Coosa coal field, exposing the underlying Lower

Carboniferous limestones and separating the Coal Measures into two distinct strips. To the south of this area of Carboniferous strata the older formations appear, highly folded and faulted, and consequently of no value as a commercially productive series. In the western corner of the county the Coal Measures reappear in the Cahaba coal field, separated from the Coosa field by a deeply eroded and faulted anticline. The county, therefore, offers no possibilities, except that of gas production in some of the numerous minor structures of the area underlain by the Carboniferous strata. (Sections 18-24, Plate II.)

DEVELOPMENT.

Only small traces of oil have been encountered in the diamond drill and other wells bored in the county. Gas shows have been more frequently found, and have occasionally been of a very promising character.

TALLADEGA COUNTY.

GEOLOGY AND STRUCTURE.

This county was not included in the impossible territory, because of the remote possibility of small gas accumulations in the highly folded and faulted Paleozoic formations, especially the Knox dolomite. All of the southeastern third of the county is underlain by the crystallines and the accumulation of either gas or oil is impossible in this part of the county.

TUSCALOOSA COUNTY.

GEOLOGY.

Throughout the southern and western part of Tuscaloosa County the Coal Measures are concealed by the gravels, sands and clays of the Tuscaloosa formation. In the northern part of the county, likewise, the Coal Measures are extensively covered, along the major divides, by this formation and the Lafayette gravels. It is only throughout about one-fourth of the county, therefore, that the Coal Measures are exposed sufficiently to enable the geologist to determine the local structure. In the southeastern part of the county the lower Paleozoic formations down to the Cambrian are exposed along the axis of the Jones Valley anticline.

STRUCTURE.

The principal structural feature of the county is the Jones Valley anticline, steeply inclined and faulted on its northern side, a typical asymmetric Appalachian fold. This fault marks the southern boundary of the Warrior coal field and also the southern limit of possible oil territory in Tuscaloosa County. The Coal Measures are locally folded, and parallel undulations are set up alongside the major Appalachian folds. Along the eastern line of the county the southern end of the Brown's Valley anticline can be traced out as a gentle warp in the Coal Measures. Throughout the whole area underlain by the Coal Measures folding seems to be abundant, where the series is sufficiently exposed to determine the structure. Scarcity of outcrops in the northern part of the county prevents the working out of structure in detail, but indications of folding are widespread. The northern and western part of the county is to be considered the most favorable for gas or oil accumulation as the fixed carbon in the coal in this area runs lower than closer in to the center of the region of disturbances. (Sections 27-28, Plate II.)

DEVELOPMENT.

Numerous wells have been drilled in the county, some of them for water, and others for oil and gas. Still others have been drilled in testing for coal and iron. In 1905 a well was drilled by the City of Tuscaloosa near the Court House, to the depth of 1,511 feet. No reliable record was kept of this well but the formations as reported are the usual succession of sandstones, shales and conglomerates of the Coal Measures. This well got a good flow of water, but no oil or gas shows were reported. Two wells were drilled in 1915 by Frederick Morck at Lock 15 in the Warrior River. The first was 900 feet deep and the second 1,900 feet, the latter encountering near its bottom a hard, black, limy shale, with faint traces of oil.

At the present time portions of the county are being examined by the geologists of one of the larger companies and acreage is being blocked up in expectation of drilling.

WALKER COUNTY.

GEOLOGY.

Walker County lies in the Plateau Region and can be included in its entire extent in the Warrior coal field. The Coal Measures do not reach the great thicknesses that are represented in Jefferson and Tuscaloosa, but along the southern line of the county as much as 2,000 feet of these sediments remain unremoved by erosion. In the northern part of the county the upper beds have been eroded, leaving about 1,000 feet of the lower strata still intact.

In the western and northwestern part of Walker County the Coal Measures are extensively covered by the gravels and clays of the Tuscaloosa and Lafayette formations. These unconsolidated sediments are usually confined to the upland areas between the streams where they effectually conceal the structure of the Coal Measures below.

STRUCTURE.

The general structure of the county is synclinal, the general dip being to the south, except where the strata are turned up abruptly along the southwestern line of the county to form the northern limb of the Brown's Valley anticline. Upon this normal south-dipping monocline there are developed numerous minor structures, which as in other parts of northern Alabama, show two general trends, northeast and southwest. At the intersection of these two series closed structures would be formed which would be favorable points for oil prospecting. (Section 18, Plate II.)

The sixty per cent. isovolve (Fig. 15) passes approximately through the center of Walker County from north to south. In Texas this sixty per cent. isovolve constitutes the dead line east of which no large accumulations of oil occur. If this holds good for Alabama only the western part of Walker County could be classed as possible oil territory, and in the eastern half where the fixed carbon is over 60 per cent. only accumulations of gas could be expected. This has been borne out by past development in the county, for only gas has been found in large quantities, though small shows of high grade oil have been encountered. The heavy oil found at Cordova is an exception.

DEVELOPMENT.

The center of development in Walker County has been around Jasper, where the Pennsylvania Oil and Gas Company drilled in 1911-1912 a number of tests locally known as the Shannon wells. Three of these wells at Jasper got gas and after being shot were estimated at about 150,000 cubic feet a day each. The producing horizon in each case was the Hartselle sandstone, encountered in this locality at about 1,800 feet. Small showings of oil were found in the Coal Measures and gas or a flow of fresh water in the Millstone Grit. The No. 1 well on the Long estate got a good show of gas in the Hartselle sandstone at 1,792 feet and was continued to 3,000 feet without other shows. This well encountered several red limestones (possibly sandstones) near the bottom and then passed into a black limestone, probably the Trenton. The log is given herewith:

Pennsylvania Oil & Gas Company No. 1 Well, Long Estate.

Located in N.W. ¼ of N.W. ¼ Section 22, Township 14, Range 7.

			Feet		*Feet*
PENNSYLVANIAN	Coal Measures	Conductor	13		
		Shale, black	13	to	50
		Sand, white	50		
		Artesian water	65		
		Bottom sand	150		
		Shale (dark)	150	to	375
		Water, sand, gas, show	375		
		Of black oil	390		
		Water, gas and show green oil	447	to	452
		Bottom sand	494		
		10-inch casing	502		
		Lime and shale with occasional sand shell a few inches thick to	652		
		Sand	652		
		Enough water to drill with (10 bailers)	661		
		Break slate	728	to	734
		Bottom sand	860		
		Slate black	860	to	900
		Sand, white	900		930
		Shale (gray)	930		987
		Sand, white, and 10 more bailers water at	1022		
		More water (8¼-inch casing)	1123	to	1150
		Bottom sand	1272		
MISSISSIPPIAN	Upper Bangor	Red shale	1272		1278
		Lime	1278		1300
		Slate (white)	1300		1306
		Lime	1306		
		6⅝-inch casing	1309–6		
		Lime, white, very hard	1309		1321
		Lime, black	1321		1330
		Lime, white, hard	1330		1771
		Slate, black	1771		1791
		Sand (steel-lime line)	1791½		
	Hartselle	Top very hard with nice showing petroleum gas, enough to run drilling well (Hartselle 100 feet thick).			
	Lower Bangor	Bottom	1891		
		Lime, white, hard	2068		
		Bottom of lime	2090		
		White lime	2100		
	Fort Payne Chert	Black lime	2268		
		Lime shell	2335		
		Slate	2343		
		Lime	2368		
		Lime	2400		
		Lime	2465		
		Lime	2580		
Devonian(?)—Lime, shell and slate			2600		

		Feet		Feet
Silurian Clinton	Red lime at top	2610		
	Red lime bottom	2790		
	Red slate	2710		
	Red lime	2720		
Ordovician Trenton	Black lime shell	2726		
	Red slate at 14 feet	2726	to	2740
	Black lime	2740	to	2850
	Break of red slate 22 feet	2850	to	2872
	Black lime	2862	to	3004
	(3003-9 actual depth.)			
	Black chocolate and gray.			
	Shut down May 9th, 1911.			

The Shannon wells were drilled in close proximity to each other and their logs are very similar. The log of well No. 3, one of the three producers, represents a typical section and is as follows:

Record of Well No. 3 of Pennsylvania Oil and Gas Company.

		From Feet	To Feet
COAL MEASURES	Clay, yellow, soft	0	14
	Slate, black, soft	14	65
	Sand, black, hard	65	80
	Sand and shells	80	110
	Sand, white	110	160
	Sand, black	160	180
	Slate and shells	180	385
	Lime, white	385	398
	Sand, white	398	405
	Lime, white	405	440
	Lime and slate	440	600
	Lime, white	600	648
	Lime and slate	440	600
	Lime, white	600	648
	Sand, white	648	858
	Slate, white	858	865
	Sandy lime, white	865	940
	Coal	940	945
	Lime, black	945	1005
	Big Injun sand	1005	1270
	Slate and shells	1270	1285
	Red rock	1285	1300
	White lime	1300	1320
	Slate, black	1320	1330
MOUNTAIN LIMESTONE Bangor	Lime, black	1330	1340
	Limestone	1340	1660
	Slate and shells	1660	1740
	Slate	1740	1800
	Jasper or Hartselle sand	1800	1812
	Gas.		
	Well finished at 1812.		

The same company drilled a 4,000-foot well near Calumet some two and a half miles south of the Shannon wells. Traces of oil were found in the Hartselle sandstone and in the Tuscumbia limestone. The log as given below is rather indefinite, but the well undoubtedly reached the Trenton limestone and probably the upper strata of the Knox.

Calumet Well, Pennsylvania Oil and Gas Company.

		DEPTH	
		Top Feet	*Bottom Feet*
COAL MEASURES	Conductor	12	—
	Hole full of water	35	—
	Slate and shale	112	—
	Coal	112	115
	Slate and shale	115	125
	Sand	125	220
	Slate and shale	220	495
	Sand	495	535
	Sandy lime	535	560
	Slate and shale	560	675
	Lime	675	690
	Sand	690	785
	Slate	785	800
	Sandy lime	800	880
	Red sand	880	900
	Sandy lime	900	940
	Slate	940	955
	Sandy lime	955	1030
	Slate and shale	1030	1065
	Sandy lime	1065	1080
	Sand	1080	1100
	Sandy lime	1100	1195
	Sand	1195	1225
	Sandy lime	1225	1315
	Sand	1315	1345
	Sandy lime	1345	1385
Bangor	Slate	1385	1405
	Lime, white	1405	1455
	8-inch casing at 1452.		
	Slate	1455	1460
	Lime, white	1460	1815
	Reduced hole at	1755	
	Lime, black	1815	1873
	Sand and shale	1873	1878
	Slate	1873	1894
Hartselle	Top of sand 3	1894	2000
	Slate and shale	2000	2050
	Brown shale	2050	2095

		DEPTH	
		Top Feet	*Bottom Feet*
Tuscumbia	Lime, white	2095	2260
	Lime, dark	2260	2278
	Sand, dark, with show of oil	2278	2284
	Lime, dark	2284	2340
	Sand, brown	2340	2350
	Limestone, sand, dark	2350	2395
	Slate	2385	2400
	Black lime	2400	2425
	Slate and shale	2425	2525
Lauderdale Chert	Lime, pink	2525	2545
	Lime, dark	2545	2595
Devonian	Slate, dark	2595	2675
Silurian	Lime, red	2675	2780
	Lime, dark	2780	2875
Trenton	Slate	2875	3000
	Lime, white	3000	3690
	Blue lime	3690	3730
	White lime	3730	3890
	Gas at	3854	
Knox (?)	Sandy lime	3920	4015

The Pennsylvania Oil and Gas Company also drilled a hole at Oakman, some ten miles southwest of Jasper. The Hartselle sandstone was here encountered at about 2,200 feet and gave a strong odor of oil and gas. The well was continued to 2,775 feet, stopping at about the base of the Lauderdale chert. The log as given shows that traces of oil and gas were found at various depths.

Log of Well No. 2 of the Pennsylvania Oil & Gas Company, Oakman, Alabama.

PENNSYLVANIAN
Coal Measures

Formation	*Color*	*Soft or Hard*	*Feet*		*Feet*
Clay	Brown	Soft	to 13		
Conductor on solid rock.					
Slate	Black	Soft	13	to	23
Water at 23.					
Shale and sand	White	Hard	23	to	53
Water at 50 feet.					
Lime, shells and slate	Black	Hard	53	to	90
Coal	Black	Soft	90	to	92
Slate	White	Soft	92	to	110
Sand	Blue	Hard	110	to	170
Sand	White	Hard	170	to	230
Sand	Dark	Hard	230	to	270
Slate	Black	Soft	270	to	330
Slate and shell	Black	Soft and Hard	330	to	374
Coal	Black	Soft	374	to	377
Slate	Black	Soft	377	to	560
Sand and lime	Black	Hard	560	to	575
Sand	White	Hard	575	to	655
Light gas show.					
Slate and shell	Black	Soft	655	to	720
Sandy lime	Dark	Hard	720	to	735
Sand	Dark	Hard	735	to	790
Slate	Black	Soft	790	to	850
Slate and hard shell	Black	Soft and Hard	850	to	885
Sand	White	Hard	885	to	925
Slate	Dark	Soft	925	to	930
Sand	Gray	Very hard	930	to	950
Rainbow of oil on rope at 954, light show.					
Sand	White	Soft	950	to	1000
Lime	Black	Very hard	1000	to	1030
Slate	White	Soft	1030	to	1060
Gritty lime	Black	Hard	1060	to	1080
Slate	Black	Soft	1080	to	1100
Slate	White	Soft	1100	to	1120
Slate	Black	Soft	1120	to	1185
Sand	White	Soft	1185	to	1200
Sand	Dark	Hard	1200	to	1245
Slate	Black	Soft	1245	to	1280
Slate and shell	Black	Hard	1280	to	1295
Sand	Yellow	Very hard	1295	to	1415
Slate	Dark	Soft	1415	to	1450
Lime	White	Hard	1450	to	1510
Slate and shells	Black	Soft and Hard	1510	to	1570
Sand	White	Hard	1570	to	1600
Light show of oil at 1572.					
Slate and shells	Yellow	Very hard	1600	to	1750
Sand	White	Hard	1750	to	1795
Sand	Black	Soft	1795	to	1800
Sand	White	Hard	1800	to	1845
Sand	Yellow	Hard	1845	to	1855

		Formation	*Color*	*Soft or Hard*	*Feet*		*Feet*
MISSISSIPPIAN	Bangor	Sand	Black	Hard	1855	to	1870
		Lime and sand	Black	Soft	1870	to	1900
		Lime	Black	Hard	1900	to	1910
		Sand	Dark	Hard	1910	to	1940
		Slate and sand	Dark	Soft and Hard	1940	to	1985
		Slate	Dark	Soft	1985	to	2005
		Caving at 1985.					
		Slate	Dark	Soft	2005	to	2049
		Slate	Dark	Soft	2049	to	2104
		Slate, lime and shells	Dark	Soft and Hard	2104	to	2135
		Lime	White	Hard	2135	to	2225
	Hartselle	Sand	Light and dark	Hard	2225	to	2295
		Lime	Black	Hard	2295	to	2385
		Strong odor of oil at 2365.					
		Slate and shell	White	Hard	2385	to	2405
		Slate	Black	Soft	2405	to	2425
		Sand	Blue	Hard	2425	to	2450
		At 2430 strong odor of oil and gas.					
		Slate	Black	Soft	2450	to	2455
		Sand	Blue	Hard	2455	to	2480
		Lime	Black	Hard	2480	to	2485
		Sand	Black	Hard	2485	to	2525
		Slate	Black	Soft	2525	to	2650
	Lauderdale Tuscumbia	Lime	Black	Hard	2650	to	2660
		Dark reddish tint.					
		Lime	White	Hard	2660	to	2690
		Sand	Black	Hard	2690	to	2705
		Lime	White	Hard	2705	to	2775

January 9, 1912, broke shaft on bed plate of engine, leaving tools in hole. Shipped in engine and still fishing for tools February 12, 1912. Stopped work that day.

The Tennessee Coal, Iron and Railroad Company drilled a test well in 1911 near Nauvoo, in the northwestern corner of the county, to the depth of 1852 feet. The Black Creek coal seam was found at 97 feet and a faint show of oil in the Tuscumbia at the bottom of the well.

Record of Test Well No. 3, Near Nauvoo, Alabama.

Location: Near center of Section 16, Township 12 South of Range 9 West.
Stopped drilling September 23, 1911; depth, 1852 feet.
Record by C. S. Blair.

			Thickness Feet.	*Depth Feet.*
PENNSYLVANIAN	Coal Measures	Surface	7	7
		Sandstone	35	42
		Slate	6	48
		Lime (probably hard black slate)	16	64
		Sandstone	10	74
		Slate	20	94
		Coal (Black Creek seam)	*3*	*97*
		Slate	3	100
		Sandstone	6	106
		Slate	6	112
		Sandstone	8	120
		Sandstone, sharp grained	20	140
		Slate	145	285
		Sandstone	45	330
		Slate	10	340
		Sandstone	18	358
		Lime (probably slate)	15	373
		Slate	77	450
		Lime (probably slate)	170	620
		Millstone Grit Formation:		
		Sandstone	65	685
		Lime (probably slate)	25	710
		Sandstone	275	985
		Sandstone, slate seams	55	1040
MISSISSIPPIAN		Bangor Limestone:		
		Limestone, pure, light colored	370	1410
		Slate	25	1435
		Limestone	90	1525
		Hartselle Sandstone:		
		Sandstone, fine grained	12	1537
		Sandstone, coarse grained	89	1626
	Tuscumbia	Slate, soft black	56	1682
		Limestone, siliceous	33	1715
		Slate, soft	102	1817
		Limestone, dark colored, very fossiliferous, petroleum odor at base	35	1852

In December, 1916, a flurry of excitement was caused throughout Alabama by the report of the bringing in of an oil well at Barney, near Cordova. At the time the production of this well was given at a variety of exaggerated figures. The well, drilled by Oklahoma parties, got a small show of heavy oil at about 830 feet (26.5° gravity Baume) and after being shot was drowned out by a flow of salt water. This show of heavy oil would indicate that a small pocket of residual oil, the lighter more volatile constituents of which had previously migrated off, had been entrapped at this point.

WINSTON COUNTY.

GEOLOGY.

The areal geology of Winston County is much the same as that of Marion County, except that the Tuscaloosa formation is much less extensive and confined to the western part of the county, and along the northern line of the county there are a few spots where the streams have cut through the Coal Measures and exposed the Sub-carboniferous. Most of the surface of Winston County is, therefore, formed by the Coal Measures, varying in thickness from a thousand feet or more in the southern and southwestern part of the county to where they are completely eroded along the northern line. The topography is fairly rugged, very precipitous valleys being developed by some of the streams in the lower sandstones of the Coal Measures, which have in some cases given rise to "rock-houses" and natural bridges (Fig. 20).

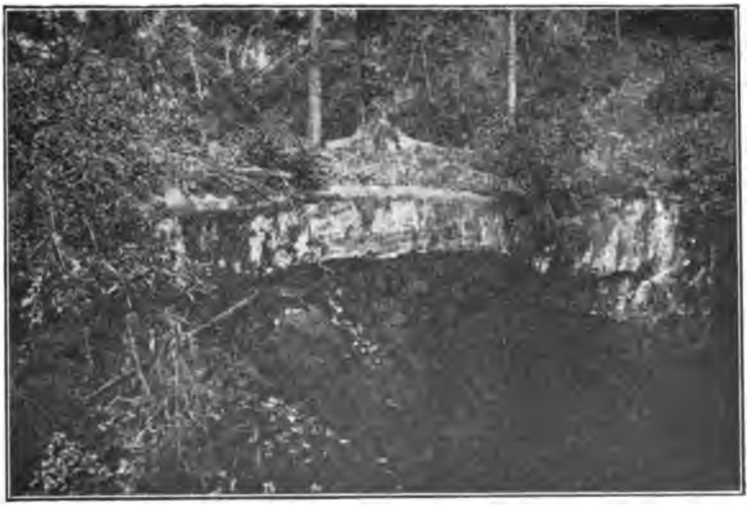

FIG. 20. A natural bridge formed by a headward erosion giving rise first to a "rock-house," which subsequently caved in to form the bridge. Near Natural Bridge, Winston County. (Photo by R. M. Harper.)

STRUCTURE.

Exposures are sufficiently numerous throughout the county to determine the structure with fair accuracy. The predominant type of fold is the northwest-southeast wave or gentle undulation that is so frequently developed in northwestern Alabama. Occasionally folds paralleling the Appalachian trend are also to be found. The gas well at Haleyville is apparently located upon one of these northwest-southeast undulations. The subsequent tests were unfortunately not made along this trend and were unproductive.

The coal from Winston County shows a comparatively low percentage of fixed carbon, an indication that the area has not been subjected to intense compression or deformation, but the occurrence of gas at Haleyville apparently indicates that what deformation has occurred has been sufficient to bring about gas rather than oil accumulation.

DEVELOPMENT.

The principal development in Winston County has been at Haleyville where several wells were drilled in 1911-1912, one of which got gas in large quantities. The other wells were apparently off the favorable structure as they were unproductive. An accurate log was made of the first well, the gasser, which is as follows:

Well No. 1, Haleyville.

Elevation: 205 feet below railroad at Haleyville—(Elliott).

Formation	*Character of Material*	*Thickness*	*Depth*
Recent	Surface soil and sand	9	9
Millstone Grit	Sandstone, white	151	160
	Shale, non-calcareous	100	260
	Sandstone and shale	85	345
	Sandstone and some shale	270	615
Bangor	Limestone, chiefly oolitic	375	990
	Shale, black, calcareous	150	1140
Hartselle	Sandstone, fine carcareous	180	1320
	Shale, gray to black, calcareous	170	1495
Tuscumbia	Limestone, cherty in part	150	1645
Lauderdale	Chert and limestone	90	1735
Devonian	Shale, black, pyritic, oily	25	1760
Niagara	Limestone, greenish white	15	1775
Clinton	Shale and limestone, red and green	260	2035
Trenton	Limestone and trace of shale	15	2050
	Shale, black to gray, calcareous	165	2215
	Limestone and shale, ferruginous	20	2235
	Shale and limestone	55	2290
	Limestone, gray to white	625	2915
Knox	Dolomite, gray, crystalline. *Gas*	25	2940
	Limestone, buff, compact	5	2945
	Dolomite, gray, crystalline. *Gas*	15	2960
	Limestone and black, oily shale	20	2980
	Dolomite, gray, crystalline	2	2982

WATER.

Fresh water to 620 feet.
Salt water from 1470 to 1620 feet.
Salt water (little) at 2725 feet.
Salt water (abundant) at 2980 feet.

GAS AND OIL.

Traces of oil and gas in the Hartselle sandstone and shale from 1145 feet to 1350 feet.

Odor of oil in Lauderdale chert, from 1645 feet to 1735 feet.

Traces of oil in Devonian shale, from 1735 feet to 1760 feet.

Odor of oil in Niagara limestone, from 1760 feet to 1775 feet.

Traces of oil and gas in Clinton shale from 1775 feet to 1845 feet.

Odor of oil in Trenton shale from 2075 feet to 2185 feet.

Gas (about 600 pounds) in Knox dolomite, from 2920 feet to 2945 feet, and from 2950 feet to 2960 feet.

The gas in the Knox was struck September 20, 1911, and November 1, 1911, after the salt water below 2980 had been effectually shut off, by plugging with lead and concrete, the well was shot in the gas horizon with 160 quarts of solidified nitro-glycerine. The flow of gas greatly and permanently increased. The closed pressure of the well is very high. The flow of gas was practically free for the first five months.

Another test was made about the same time by the Woodward Oil and Gas Company near Double Springs in the center of the county.

Well No. 3, Near Double Springs.

SUMMARY RECORD.

Formation	*Character of Material*	*Thickness*	*Depth*
Coal Measures and Millstone Grit	Sandstone and shale	670	670
Bangor	Limestone and shale	460	1130
Hartselle	Sandstone	180	1310
	Shale and limestone	150	1460
Fort Payne	Limestone and chert	310	1770
Devonian	Black shale	20	1790
Clinton	Red and green limestone and shale	150	1940
Trenton	Shale, limestone and shale	40	1980
	Limestone	170	2150
	Shale	30	2180
	Limestone	260	2440

PART II

COASTAL PLAIN AREA

BY

J. EDWARD BRANTLY

PART II

COASTAL PLAIN AREA

By J. Edward Brantly.

INTRODUCTION.

IN STUDYING the Coastal Plain area of Alabama with reference to its possibilities of producing petroleum in commercial quantities, no attempt has been made to give the relative values of the logical subdivisions, except in a very broad manner. This has been done primarily to prevent the useless expenditure of the necessary sums for prospecting in areas where it seems improbable that commercially profitable deposits of oil and gas will be discovered. Because of the fact that there has been comparatively little testing for oil in the southern half of Alabama, it is necessary to present the conditions primarily from the information that can be gathered along the surface terranes of the various formations which compose the Coastal Plain. Each formation has been described in sufficient detail to allow those interested in the subject to draw their own conclusions without the necessity of making studies in the field. At the same time these descriptions are presented in such a manner that those studying the field conditions will be readily able to recognize the horizon in which they are working. The formations which are considered to have the most favorable outlook for production are presented briefly in the latter part of the report accompanied by the logs of certain wells that have been drilled in the Coastal area. The known structures in the Coastal Plain are discussed with the idea of broadly delimiting them for the assistance of those working in the field rather than for the purpose of describing areas in which exploration is justified.

The writer wishes to acknowledge the great assistance given him by Dr. Eugene A. Smith, State Geologist of Alabama, both through the medium of his writings on the

Coastal Plain area and consultations with him during the preparation of this report, also it is wished to acknowledge the use of publications by D. W. Langdon, L. C. Johnson, L. W. Stephenson, G. C. Matson, E. W. Berry and C. W. Cooke. Proper reference is given to these authors and their publications where data have been secured from them.

SUMMARY.

As a result of the study of the possibilities of petroleum in the Coastal Plain area, that part of the State has been divided into several districts, each of which has conditions peculiar to itself. The possible sands have been studied broadly, and the structural deformation considered to the extent permissible with the data at hand. It is found that the only structure that has been tested did not yield oil, nor did the tests lend much encouragement to further exploration even though the most promising area of the anticline has not been drilled through the chalk. In Eastern Alabama it was found that the possible sand horizons should be considerably thicker than in the western part of the State, and, therefore, the chances for success proportionally greater. Several folds that give promise of proving to be good structures are outlined: the Lower Peachtree Anticline, the Beatrice Anticline and the Geneva fold. Also the Hatchetigbee and Jackson structures, which are more completely described elsewhere, are considered. In conclusion the work has shown that there are areas in which are structures; capable of acting as traps for the accumulation of oil, overlying sands that may be petroliferous and are within easy reach of the drill.

LOCATION.

The Coastal Plain area of Alabama is all of that portion of the State between the Fall Line, where the streams run out of the hard rock and into the soft rock countries, and the Gulf of Mexico on the south and the Mississippi line on the west. In area it comprises about two-thirds of the total area of the State. Along the northern border of the plain area there is only a thin mantle of the Coastal Plain material through which the streams have cut into the older Coal Measures and metamorphosed rocks below, in such a manner that no definite line can be drawn separating the

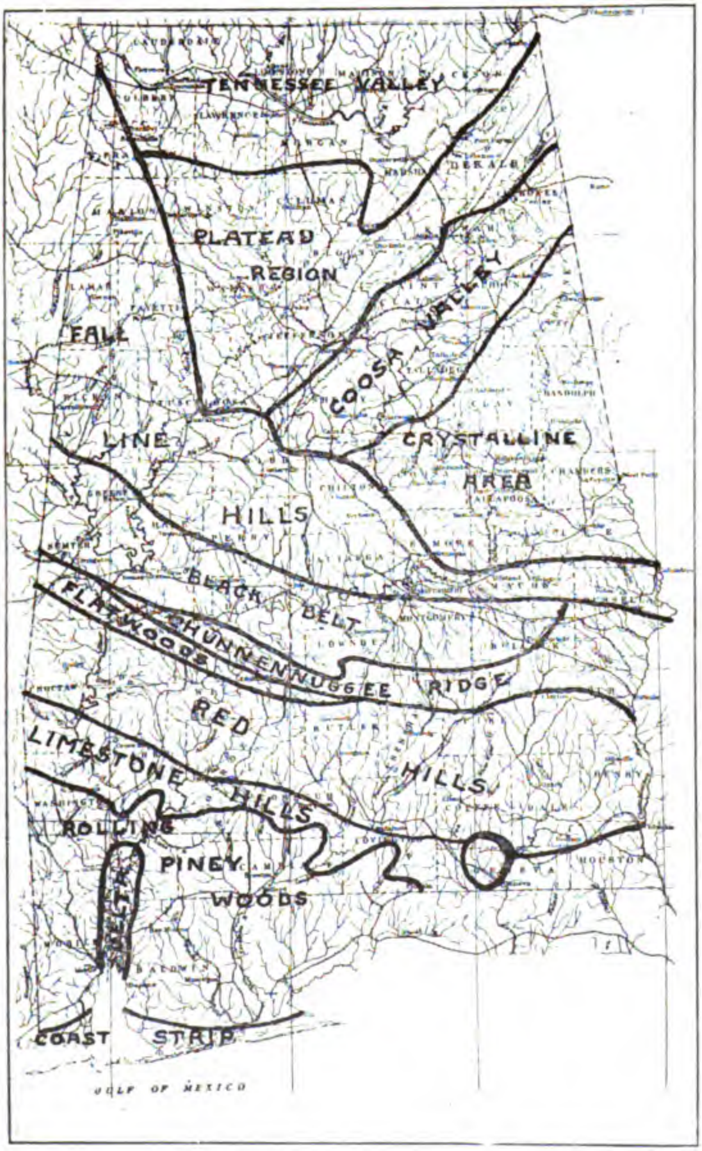

FIG. 21.—Topographic subdivisions of Alabama.

provinces. Roughly a line drawn from the point where the Tennessee River touches the Mississippi line to Tuscaloosa, thence southeast and east to Wetumpka, thence east to Columbus, Georgia, is the line of division. Generally soft materials from Lower Cretaceous to Recent age make up the entire thickness of Coastal Plain deposits.

TOPOGRAPHY.

In a broad sense the Coastal Plain of Alabama is a slightly undulating plain sloping gently southwestward from an elevation of about 600 feet along the Fall Line or the landward limit of the Coastal Plain formations, to sea level along the Gulf of Mexico. Following this general inclination the primary drainage channels, with a few exceptions, have a flowage direction about S. 30° W., which is parallel to the axes of the Appalachian Uplift and the Valley Region anticlines. This is what might be called the normal direction of drainage, it being at right angles to the old shore lines from Cretaceous to Pleistocene times. The Alabama River and the smaller streams in the southeastern part of the State are the most consistent in this general direction while the Chattahoochee and Tombigbee-Warrior both show the general trend in long reaches along their courses. Of secondary importance to this normal direction of drainage is a flowage trend about S. 30° E., which shows in long reaches on the Alabama River. Along this latter stream this direction is evidently caused by certain structural movements which are discussed in a later chapter of this report. The only considerable variation from these two directions of drainage is in the case of the Alabama River and its tributary, the Tallapoosa, which flow westerly from Millstead past Montgomery and to Selma. This was possibly influenced by the Selma Chalk which acted as a dam, turning the Tallapoosa westward at Millstead. From that point the Tallapoosa and then the Alabama flow across the terrane of the Selma Chalk to the city of Selma where the latter stream turns southwest, passing across the Selma Chalk and into the overlying Ripley formation in the southwestern part of Dallas County. From here to the Gulf of Mexico the southwesterly direction is maintained.

The Coastal Plain of Alabama while being on the whole a gently sloping country is readily subdivided into a number of areas having separate and distinct topographic features which are imparted to them by the character of materials of the geological formations composing the surface terrane of the different areas. Following Smith* and Harper,† with certain modifications consistent with the major topographic features, the Coastal Plain is subdivided into nine provinces which are described briefly below:

Fall Line Hills.—Southward from the landward limit of the Cretaceous formations or the contact of the Cretaceous with the older formations of northern Alabama, there is a belt of hilly country having a maximum elevation of about 600 feet above mean sea level and a maximum relief of near 400 feet above the main drainage channels. These hills are made up of sands, clays and gravels of the Tuscaloosa and Eutaw formations with Lafayette materials frequently capping the higher points. The streams cross this area from the northern part of the State and usually have, besides the University and Northport terraces, wide flood plains and swamps along their courses. The sandy nature of the materials which make up the area, having the capacity of holding abundant supplies of meteoric waters, give rise to numerous small streams and branches which have further assisted in the dissecting of the area into steep and rugged surfaces. In the northwestern part of Alabama where a comparatively thin mantle of Tuscaloosa covers the Coal Measures the elevation reaches a maximum of near 1,000 feet above sea level. This is, however, a comparatively small portion of the belt.

Black Belt or Prairie Country.—Lying next south of the Fall Line Hills and extending slightly south of east from the Mississippi-Sumter County line to the eastern part of Bullock County there is a belt of gently rolling prairie land known as the "Black Belt." This area is the entire surface terrane of the Selma Chalk and has an approximate width of 15 to 20 miles. Upon weathering the chalk yields a tough yellow soil which, owing to its fertility and the resultant abundant vegetation, has stored up sufficient humus in the top soil to give it a deep black color. This area is quite similar in appearance to the black prairie country of the

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*Smith, Eugene A., Physico-Geographical and Agricultural Features of Alabama, Tenth Annual Census of the United States, Vol. VI, 1880.

†Harper, Roland M., Economic Botany of Alabama, Part I, Monograph 8, Geological Survey of Alabama, 1913.

Eagle Ford, Austin Chalk and Taylor marl districts in Texas. The prairie belt in Alabama is gently rolling with occasional more or less prominent hills resulting from local indurated parts of the chalk.

Chunnennuggee Ridge.—Extending across the State from the Tombigbee River to the Chattahoochee in southern Russell and northern Barbour Counties there is a strip of country characterized by a rather hilly topography, which is in effect a ridge supported by the indurated ledges of the Ripley formation. The name is derived from Chunnennuggee Ridge south of Union Springs. Along the Chattahoochee this subdivision occupies the eastward extension of the Black Belt and is very similar in all features except the nature of the soil which is a tough yellow clay in the Ripley area. The hills of this belt are frequently very steep and reach an elevation of 300 feet above the level of the main drainage channels. A good example of the type country is in the northern part of Wilcox County.

Post-Oak Flatwoods.—The Flatwoods extend in a narrow belt southeastward from Sumter County to near the Louisville and Nashville Railroad in Butler County north of Greenville. The area is generally flat to gently rolling with a tough reddish clay soil derived from the underlying Sucarnochee clays. Post Oak is the predominating growth.

Southern Red Hills.—This belt, extending entirely across the State, composes practically all of that area in which the formations of Eocene age come to the surface and has a rather uniform width of near 35 miles but exceeding this somewhat in the eastern part of the State. In the eastern part of the belt the name here used is descriptive of the topography while in the area west from Butler County the belt is composed of several east-west ridges supported by the indurated parts of the formations which come to the surface. The most typical of these ridges are the Grampian Hills south of Camden and the Tallahatta Hills in Clarke and Monroe Counties. The first of these is supported by the indurated beds of the Nanafalia formation while the latter is the result of the calcedonized layers in the upper part of the Tallahatta Buhrstone. In broader consideration these ridges are cuestas with the steep scarps on the north and the gentle dip slopes to the southward. However, the highly dissected nature of both ridges obliterates the actual resem blance to true cuestas. The hills are generally very steep

FIG. 22.—CHATTAHOOCHEE RIVER SECTION.

Based on Section made by D. W. Langdon.

Recent and Quaternary		First Bottom	River flood plain and stream gravels and sands and red, chocolate and black silts and clays. Thickness 0-40 feet.
	Pleistocene	Columbia Group Terraces: Northport Terrace (2d) University Terrace (3d)	Sands, clays and gravels of second and third stream terraces. (Satilla and Okefiinokee of Georgia), 50 to 60 and 100 to 150 feet above stream levels.
	Pliocene	Lafayette Group	Gravels, sands and clays resting on all formations from the crystalline and Paleozoic rocks to and including those of Pliocene age. Some of the sands, clays and gravels possibly represent deposits of early Pliocene age in southeast Alabama.
Cretaceous	Upper Cretac Gulf Seri		*plumosa*, *Inoceramus*. Thickness estimated to be about 950 feet.
		Eutaw formation (Unconformity)	Sands and clays of marine origin. Tombigbee sand member 150 to 200 feet thick at top. Beds generally greenish. Fossiliferous. Thickness, 550 to 600 feet.
	Lower Cretaceous or Comanchean	Tuscaloosa formation	Langdon placed the continental sands and clays below the Eutaw in the Tuscaloosa formation (Upper Cretaceous) while Stephenson on later study considers them to be of Comanchic or Lower Cretaceous age. Thickness, about 350 feet.

true cuestas. The hills are generally very steep

Cretaceou	Upper Cretac	Selma Chalk	massive argillaceous limestone or chalk. Fossils: Exo-gyra costata, *E. ponderosa*, *Ostrea larva*, *O. plumosa*, *Inocerami, etc.* Thickness, 800 to 1,000 feet.
		Eutaw formation Unconformity?	Clays and sands of marine origin, calcareous at top. Fossiliferous. Thickness, 300 feet.
		Tuscaloosa formation	Unconsolidated sands, usually cross-bedded and massive clays of continental origin. Leaf impressions. Thickness, 1000 feet.

Cretaceous

ceous or
Series

blance . The hills are generally very steep

AGE	SERI
Recent	
Quaternary	Pleistoc
Tertiary	Pliocene
	Miocene
	Oligocen
	Eocene
Cretaceous	Upper C ceous or Series

blanc

and afford excellent exposures of the supporting formations. The relief is as much as 250 or 300 feet.

Southern Limestone Hills.—This subdivision extends as a narrow strip across the State from the Mississippi line to the Chattahoochee River in the extreme southeastern part of the State. In the western portion of the belt the country is hilly while to the eastward the topography becomes more rolling to flat and is frequently covered with sands and clays of more recent age than the Jackson and Vicksburg formations which are the surface-making formations. In this section there are also numerous limesinks from which the name "Limesink Region" was derived and used in both Alabama and Georgia.

Rolling Piney Woods Country.—This subdivision composes all of that upland part of the State south of the limestone belt and is the area of outcrop of all of the formations from Grand Gulf to Pleistocene age. The topography is generally gently rolling to flat with sandy to sand-clay soils. The maximum elevation of the area is some 250 feet above sea level.

Mobile Delta.—This area is the lowland of the delta of the Mobile River south of the confluence of the Alabama and Tombigbee rivers.

Coast Strip.—The narrow sandy lowland strip and islands along the coast have been named the Coast Strip.

AREAL GEOLOGY.

GEOLOGICAL SECTIONS.

The columnar section headed "Chattahoochee River Section" is compiled primarily from the section made by D. W. Langdon, formerly of the Alabama Geological Survey, and is representative of all strata with their thicknesses as seen by him on a tour down the Chattahoochee River. It is probable that the total thickness of the entire section is somewhat greater than is indicated by Langdon. However, this difference cannot be very considerable and this section is fairly representative of the character of materials of the formations which compose the Coastal Plain of Eastern Alabama together with their respective thicknesses. The section as given by Langdon is included in this report (Figure 22).

The Alabama and Tombigbee River sections (Figure 23) have been compiled from the work and publications of Dr. Eugene A. Smith, while the area has been recently studied and checked by the writer from the Tuscaloosa formation upward through the series to the base of the Vicksburg group. From the base of the Selma Chalk to the top of the Jackson a complete section of the strata was seen and noted almost foot by foot, which leaves little room for error in the character of the materials as given with the respective thicknesses of the various formations. A slight hiatus exists between the Nanafalia formation and the Tuscahoma formation which, however, cannot concern more than 20 to 25 feet of beds. The contact of these two formations was definitely seen in Marengo County but was covered along the Alabama River. This section is composite of the exposures along the Alabama and Tombigbee Rivers and the contiguous areas. Above the St. Stephens group the data as given, have been compiled from publications by various authors. The logs of wells drilled in this area have been used to check the thicknesses of the various formations and therefore we can be reasonably certain of the accuracy of the figures given.

On Figure 24 there is given a correlation table of the formations from the base of the Upper Cretaceous to the recent deposits, extending across the Gulf Coastal Plain from East Texas to the Atlantic seaboard in Georgia. No attempt has been made to make a minute correlation based on the paleontologic characteristics of the different formations but the table is presented primarily from the standpoint of the lithology without, however, neglecting the broader consideration of the fossil content of the various horizons. An attempt has been made to show broadly the upward-eastward transition of the Austin Chalk which occurs in the upper lower half of the Gulf Series in Texas, to the Selma Chalk of Alabama which occupies in part, that horizon from middle Austin to the top of the Upper Cretaceous.

CRETACEOUS SYSTEM.

The surface terrane of Cretaceous strata in the Gulf Coastal Plain beginning on the eastern border of Georgia extends in a southwesterly direction to the Chattahoochee River thence west and northwest across Alabama, northward through the northeast corner of Mississippi, thence slightly east of north, through Tennessee and bending westward to the vicinity of Cairo, Ill. Underlying and outcropping immediately north of the Cretaceous Terrane from Central Alabama, northeastward through Georgia, are metamorphosed rocks of the pre-Cambrian Piedmont Area. Northwestward from Central Alabama Paleozoic beds immediately underly the Cretaceous.

This trend of Cretaceous outcrop defines in effect a great monoclinal nose caused jointly by the Appalachian Uplift and the Mississippi Embayment. This great nose was not formed by an pulift subsequent to the deposition of the Coastal Plain strata but rather by movements prior to this deposition causing shore lines which conformed to the present line of outcrop of the Cretaceous strata. Correctly speaking, this might not be termed a "nose" but since the dips conform in general direction to a true monoclinal nose the effect and appearance is the same and might be so considered. The axis of this regional structure has a direction parallel to or is the southwestward extension of the axis of the Appalachian Mountain system and the great anticlinorium of which the Birmingham Anticline is a member. The axial trend is about North 30° East-South 30° West.

Northward of the Coastal Plain area of Alabama, where strata of Cretaceous to recent age make up the land surface, rocks from Cambrian to Pennsylvanian-Pottsville age are exposed in the valley regions and coal areas while metamorphosed Archean to Cambrian sediments and later igneous rocks cover the surface of the Piedmont area of eastern Alabama. No deposits of materials of the periods between the Pottsville and Cretaceous seas occur within the State or in fact in the southeast with the exception of North Carolina and Virginia, where Triassic beds are present.

This absence of Jurassic, Triassic and Permian strata is indicative of the fact that during those periods of time the present Piedmont Plateau, Cumberland Plateau and the Palezoic areas of the southeast composed a land area which probably extended considerably further southwestward than the present limits of these areas. It is likewise probable that the southeastern limit of the Piedmont area was much further southeastward than the present Fall Line or the contact between the crystalline rocks and the Cretaceous sediments. This land mass possibly extended a considerable distance further eastward than the present land area of the southeastern United States.

In early Comanchic times there seems to have been a rapid transgression of the sea upon the land area reaching an inland limit somewhat north of the present Lower Cretaceous-Piedmont contact in Georgia and eastern Alabama and south of the Upper Cretaceous-Paleozoic contact in Middle and Northwestern Alabama. The northern limits of the Lower Cretaceous have not been defined in the two last mentioned areas because of its being overlapped by Upper Cretaceous strata and no wells having penetrated the Lower Cretaceous formations. The western limit of the Lower Cretaceous strata in Alabama, according to Berry,* is along the eastern line of Autauga County which is also approximately the western limit of the Pre-Cambrian area. This is suggestive of the possibility that the Lower Cretaceous shore line continued westward or southwestward around a southwest extension of the Paleozoic and Piedmont land mass. We would then expect to find Lower Cretaceous beds below the Upper Cretaceous somewhere south of the present landward margin of the Tuscaloosa formation. At the beginning of the Lower Cretaceous time the Cretaceous shore line changed very little along the Piedmont land area but transgressed for a considerable distance inland over the Paleozoics in Alabama and northward almost to the Ohio River.

The Tuscaloosa beds, the lowest member of the Upper Cretaceous series, are apparently resultant from deposition by rather numerous streams or one or more very large rivers having a rapid run off from the Paleozoic land area. These crossbedded and discontinuous sands and clays seem to have been dropped by the streams as the foot of the steep fall of the stream channels, probably in shallow fresh waters, as delta deposits or as a continental fan. A luxuriant floral growth in shallow and fresh water marginal swamps is indicated by the rather abundant plant remains in the Tuscaloosa clays in some localities. No marine fossils have been found.

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*Berry, E. W. "Upper Cretaceous Floras of the Eastern Gulf Region in Tennessee, Mississippi, Alabama, and Georgia," U. S. G. S., Prof. Paper 112, 1919.

The Tuscaloosa interval ended with a sinking of the near shore sea floor and the inundation of the marginal swamps and lakes with a consequent transgression of the shore line, hardly further, or as far, inland as the present landward limit of the Tuscaloosa sediments. In this sea the marine Eutaw sands and clays were deposited. The cross-bedded and discontinuous nature of the Eutaw sands and clays indicate a rather perturbed sea, quite similar in effect to the conditions under which the Tuscaloosa beds were deposited, but in marine waters. In fact, it might be considered that the Tuscaloosa and Eutaw formations were deposited under very similar conditions of drainage and transportation with the Tuscaloosa in marginal fresh water bodies, and the Eutaw in shallow sea water that had transgressed inland covering the Tuscaloosa fresh water marshes. The Eutaw beds extend a hundred or more miles further eastward than the Tuscaloosa and here rest unconformably upon the Lower Cretaceous strata.

Toward the end of the Eutaw deposition there was a very marked change in the drainage conditions off the Paleozoic area. Where the major streams had originally paralleled the axis of the Appalachian Uplift, bringing the greatest quantity of land wash to the southwest end of the Paleozoic land area, they now were diverted northwestward and southeastward. The possibility presents itself that the Tennessee River, which had found an outlet to the sea through or near the present Warrior River channel, was, at the end of the Eutaw, diverted northwestward at Guntersville, emptying into the Mississippi Bay in the extreme northwest corner of Alabama. At the same time the principal drainage systems of the Piedmont area were the Chattahoochee River and other streams to the east. A slight landward transgression of the sea around the point of the Appalachian peninsular also took place about this time.

The result was that small streams carrying little burden emptied into a quiet, rather shallow sea extending from the Tennessee line in Mississippi southeastward and eastward through Mississippi and Alabama to near the Chattahoochee River. These streams drained limestone areas of the Paleozoic region and in consequence transported in solution comparatively large quantities of calcium carbonate, which, together with minute clay particles, was deposited largely through the medium of organisms as a massive impure chalk bed reaching a maximum thickness of upward of 1,000 feet. This condition of deposition was continuous for some distance seaward since wells in Clarke County, Alabama and near Jackson, Mississippi, both 75 miles south to southwest of the seaward margin of the chalk outcrop, have penetrated the Selma, which shows a thickness of 950 feet in the first mentioned location, while wells penetrated about 500 feet and yet in the chalk near Jackson. The possibility of seaward transgression into chalk of the Eutaw sands and marls is eliminated by the uniform thickness of the Selma Chalk. A transgression would have resulted in an increased thickness seaward which is not shown by the available data except possibly in the Empire well on the Hatchetigbee Anticline.

The base of the Selma Chalk to the eastern limit in Russell County is a persistent horizon while eastward from Montgomery County to Russell County, the chalk decreases and the Ripley sands increase in thickness, occupying the upper horizon of the chalk zone and finally in Russell County and Georgia, including the entire horizon. Eastward of the chalk at the beginning of the Selma deposition the drainage channels had a rather rapid run off, bringing sands and clays in suspension and depositing them in a less quiet sea than the Selma waters. This condition of Riply deposition gradually became more effective with time, finally extending its character of sediments across the State to the Tombigbee River.. Between the Tombigbee and Alabama Rivers the Ripley is both underlain and overlain by the Selma Chalk. The upper tongue of chalk is the medium forming the strip of black prairie soil extending eastward from Linden to near the Alabama River. Both Berry* and Stephenson have concluded that the Ripley finally merges into the Selma Chalk near the Tombigbee River and does not persist again as a distinct lithologic unit between the Tombigbee and Macon, Mississippi. Smith mapped the Ripley entirely across Alabama though he did not recognize it as a distinct lithologic unit west of the Tombigbee River.

The conclusion is that while the Selma and Ripley formations are distinct lithologic units, they occupy the same stratigraphic position and might logically be included as a "Group." In western Alabama the chalk occupies the entire horizon and in eastern Alabama the Ripley marls and sands made up the entire thickness. The Selma Chalk is the more persistent in the lower portion of the horizon, while the Ripley predominates in the upper part. The fossil zones are persistent through the horizon regardless of the character of the material. A more extensive original distribution northward of materials of the Ripley character in the Selma-Ripley horizon seems highly possible and on this basis of reasoning down the dip of the Selma-Ripley, particularly in middle Alabama where the sandy marls are comparatively thin, the Ripley may merge into the Selma Chalk, though it is not definitely shown by the records of wells drilled.

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*Loc. cit. Prof. Paper 112, U. S. G. S.

The foregoing study of the Cretaceous history is presented, not as a detailed and minute consideration of the controlling factors of Cretaceous times, but rather as a broad presentation of the possible major conditions of sedimentation to enable the reader to draw more readily conclusions as to the problems to be encountered in field studies in Alabama and their relation to the possibilities of the occurrence of petroleum. The presentation here given is based primarily upon the mechanics of the deposition of the various classes of sediments and the geography and topography of the affected areas without particular consideration of the paleontologic evidence.

The next few pages are devoted to a rather brief study of the principal characteristics of the Cretaceous formations, each taken separately.

UPPER CRETACEOUS.

The Cretaceous formations of Alabama outcrop as a belt ranging in width from somewhat more than fifty miles along the Chattahoochee River, the eastern boundary of the State, to a width of about one hundred thirty miles along the Mississippi line, the western boundary. The general direction of the belt is slightly north of west from the Chattahoochee River to Selma thence northwest to the Mississippi line. The Cretaceous is limited on the north and east by the Pre-Cambrian metamorphic or crystalline rocks and formations of the Paleozoic system from Cambrian to Carboniferous age, inclusive.

There are four distinct phases of the Cretaceous in Alabama that have each been given a formation name because of the characteristics of the different units and the conditions of deposition. Based on stratigraphic position and paleontologic evidence all of these formations are considered to be Upper Cretaceous age with the exception of the beds underlying the Eutaw formation in the eastern part of the State which have been determined to be of Lower Cretaceous or Comanchic age by E. W. Berry, who studied leaf impressions collected at Old Fort Decatur, Macon County, Alabama, by L. W. Stephenson.* The four subdivisions of the Cretaceous in Alabama in ascending order are as follows:

1. The *Tuscaloosa formation,* consisting of continental and marginal fresh water cross-bedded sands and vari-colored clays.
2. The *Eutaw formation,* composed of marine clays, sands, and glauconitic sands. The upper portion becomes calcareous. Fossils are frequent in certain horizons.
3. The *Selma Chalk* or *Rotton Limestone,* consisting of marine argillaceous limestone with more or less abundant faunal remains.
4. The *Ripley formation,* composed of sands, argillaceous sands, glauconitic sands and thin beds of hard calcareous sandstones or marl. Fossils are numerous in certain horizons.

The two species of Exogyra, *Exogyra costata* and *Exogyra ponderosa* are the most characteristic fossils of the Upper Cretaceous and on the basis of these the correlation of the Cretaceous of Alabama and Texas are made. In Alabama the lower limit of Exogyra costata is about the middle of the Selma-Ripley horizon or 500 feet below the top. This also marks the upper limit of *Exogyra ponderosa* which has its lower limit in the upper portion of the Eutaw formation. In Texas the lower limit of *Exogyra costata* and the upper limit of *Exogyra ponderosa* is about the top of the Taylor Marl or the base of the Navarro formation. The base of the *Exogyra ponderosa* zone is in the middle part of the Austin Chalk in the Austin-Dallas country. Therefore, from the fossil content as well as stratigraphic position the upper half of the Selma-Ripley formations of Alabama is equivalent to the Navarro formation of Texas while the lower part of the Selma-Ripley is the time equivalent of the Taylor Marl and the upper half of the Austin Chalk. The Eutaw of Alabama is correlated with the lower half of the Austin and the Eagle Ford of Texas. The exact corresponding limits of these formations are not known. The Woodbine of Texas and the Tuscaloosa of Alabama are correlated together, each being the basal formations of the Upper Cretaceous or Gulf Series in their respective areas of outcrop, though the conditions of sedimentations were quite different.

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*Otto Veatch and L. W. Stephenson, Geology of the Costal Plain of Georgia, Bull. No. 26, Geological Survey of Georgia, 1911, page 77.

TUSCALOOSA FORMATION.

This formation, including the Lower Cretaceous in Eastern Alabama, outcrops in a belt extending from Columbus, Georgia, on the Chattahoochee River, westward and northwestward to the Mississippi line, being the northernmost of the Coastal Plain formations. The width of the surface terrane varies from ten or twelve miles on the Chattahoochee River (Lower Cretaceous beds) to fifty or sixty miles in the northwestern part of the State. This area is characterized by a generally steeply rolling to hilly topography with frequent deep gullies which together have occasioned the name, "Fall Line Hills" in the southeast. The maximum relief is near three hundred feet with the high points along the Fall Line ranging from 500 to 600 feet above sea level.

The materials of the Tuscaloosa formation consist of vari-colored, massive and semi-laminated clays and sandy clays, cross-bedded and massive sands and small pockets or lenses of gravel. In the lower portion of the formation clays predominate while the sands are more abundant in the upper part. The pebble or gravel pockets are scattered practically throughout the formation but make up an inconsiderable proportion of the whole. Along the northern edge of the terrane where the Lafayette gravels lie directly upon the Tuscaloosa, it is frequently difficult to distinguish between the two. In general the Tuscaloosa gravels are less rounded than the Lafayette while again the Lafayette seems to be the reworked materials of the Tuscaloosa formation.

Some of the clay beds contain abundant plant remains while thin strata of lignitic material interbedded with the clays are not infrequent. The absence of marine fossils, together with the nature of the materials exposed indicate or show that the beds are of continental or marginal fresh water and delta origin.

The Tuscaloosa materials weather into red clay, sand-clay and sandy soils.

There are no definite means of accurately computing the thickness of the Tuscaloosa beds since no wells have entirely penetrated the strata, and correlations from one well to another are impracticable because of the rapid gradation from one material to another and the absence of fossils. Hence it becomes necessary to make the determinations on the basis of the rate of dip per mile, which is only approximate, and the width of the outcrops. The normal rate of dip of the Tuscaloosa formation is estimated to be from 35 to 40 feet per mile. Along the Chattahoochee River where the Lower Cretaceous outcrop has a width of ten to twelve miles we would then have an approximate thickness of 400 feet which obtains westward to Wetumpka, the western limit of the Comanchean. In the Maplesville section the strata are near 750 feet thick, which increases to between 900 and 1,000 feet south of Tuscaloosa and on the Mississippi line.

The section given below is typical of the lower portion of the Tuscaloosa formation.

**Section above Saunders' Ferry, Black Warrior River, 8 miles southwest of Tuscaloosa.*

6.	Rather massive clays of greenish and purple colors, breaking with conchoidal fracture. On drying these clays become hard and rock-like, resembling then, except in color, some of the claystones of the Buhrstone formation. These clays when wet soften and slide down the slopes, covering them completely in places. In this clay we find many rounded masses of ferruginous and siliceous matter of oolitic structure. Thickness of the clays	40 feet
5.	Laminated, sandy clays, gray, with partings, lignitic This bed is rather more coherent than the underlying and forms a slightly projecting or overhanging ledge.	5 feet
4.	Gray, cross-bedded sands, with partings of clay along many of the planes of false bedding, lignitic, leaf impressions	25 feet
3.	Slope or bench forty to fifty feet wide, covered by red clay and sands, slidden down from No. 1 and washed out of Nos. 2 and 3	3 feet
2.	Gray or whitish, cross-bedded sands, forming the immediate bank of the river	15 feet
1.	Blue, micaceous sands to water level	5 feet

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*Smith, Eugene A., "Geology of the Costal Plain of Alabama," Geological Survey of Alabama, 1894, page 316.

EUTAW FORMATION.

The surface terrane of the Eutaw formation is a continuous belt from 8 to 10 miles in width, lying immediately south of the Tuscaloosa and Lower Cretaceous outcrops, and extending westward from the Chattahoochee River to the Selma meridian, thence northwestward to the Mississippi line east of Columbus, Mississippi. The most characteristic materials of the formation are bluish laminated clays and bluish to greenish laminated sands with occasional calcareous, fossiliferous beds and greensand marl. These sand and clay beds are very unusual in the manner in which they grade rapidly from one to the other or break off on almost a sharp line, the same horizon continuing as sand or clay as the case might be. This prenomenon is well exhibited in practically any exposure of considerable length and in the logs of wells drilled within a short distance of each other.

The upper 25 to 30 feet of the formation consist of calcareous sands and glauconitic marls, generally fossiliferous. Eastward of the eastern limit of the Selma Chalk the upper beds of the Eutaw formation become less calcareous. These calcareous beds evidently mark the change in conditions of sedimentation between the Eutaw and Selma.

Next below the calcareous beds are some 150 to 200 feet of sands and argillaceous sands which have been called the Tombigbee Sand member. Next below are some 200 feet of strata with laminated clays predominating. Eastward towards the Chattahoochee this lower portion becomes more sandy.

The Eutaw formation is evidently of marine origin containing more or less frequent fossiliferous beds, the principal fossils of which are *Ostrea Cretacea* Morton, *Ostrea plumosa* Morton, *Exogyra cancellata* Stephenson, *Exogyra ponderosa* Roemer, *Gryphaea aucella* Roemer, *Inoceramus*, *Cardium sps.*, *Corbula crassiplica* Grabb, etc., etc. Lignitic material, leaf impressions and lignitized wood are frequently found in the laminated clays and sandy clays.

The Eutaw materials form sandy soils along the southern part of the outcrop and yellow to reddish sandy clay soils in the northern portion.

The thickness of the Eutaw has been variously estimated at from 250 to 600 feet. There are no positive data available from which to compute the thickness with any considerable degree of accuracy, hence it is necessary to estimate a rate of dip per mile and calculate the thickness from the width of the surface terrane. Along the Selma meridian the width is approximately ten miles, which considering the dip, 30 to 35 feet per mile, would indicate a thickness of near 300 feet. In a water well at Selma the thickness seems to be somewhat less than this. Eastward toward the Chattahoochee River the Eutaw increases to a possible maximum of 500 feet while near the Mississippi line the thickness is probably near 400 feet.

SELMA CHALK.

The Selma Chalk outcrops in a belt from 20 to 30 miles wide, extending from the western edge of Russell County, westward to Selma, thence northwestward to the Mississippi line and lying immediately south of the surface terrane of the Eutaw formation. The material composing the Selma is primarily massive white argillaceous limestone and chalk of shallow water origin. Blue calcareous clays are also present in small thicknesses. The chalk is of a bluish color when wet and white to cream colored on dry oxidized exposures. Excellent exposures of the formation may be seen along any of the streams traversing its outcrop, along road cuts and in eroded spots in cultivated fields and prairies.

The soil derivative of the Selma Chalk is a yellow clay normally, but is usually black due to the presence of humus. These soils resemble very closely the soils of the Austin and Annona chalks and Taylor Marl of Texas but are not, as a whole, black to as great depth because of lesser quantities of humus. The topography is normally the gently rolling prairie type.

The maximum thickness of the chalk, based on an average dip of 30 feet per mile, is somewhat more than 1,000 feet. This maximum is probably reached in the area between the Alabama River and the Mississippi state line. Eastward from the Alabama River the chalk gets gradually thinner and disappears entirely near the western edge of Russell County. Westward from the Tombigbee the thickness as shown by an artesian well at Livingston, is 930 feet. A thickness of somewhat less than 900 feet is indicated by the record of a well near Myrtlewood, Marengo County. At

Camden, Wilcox County the chalk is somewhat more than 900 feet. At Union Springs the thickness is 515 feet. Eastward from this point the chalk thins rapidly until it disappears by merging along the strike into the Ripley marls.

The Selma Chalk is fossiliferous throughout, the principal family being the oyster, the most abundant of which are *Ostrea larva, Ostrea plumosa, Exogyra costata* (in the upper part) and *Gryphaea vesicularis.* Inoceramus and many other genera are likewise present. The faunal life is similar to but somewhat more abundant than that of the underlying Eutaw while the overlying and contemporaneous Ripley formation has the same fossils as the Selma.

RIPLEY FORMATION.

The Ripley formation or Ripley marl lies stratigraphically above the Selma Chalk throughout the extent of this formation in Alabama east of the Tombigbee River. Eastward of the east limit of the Selma Chalk, the lower portion of the Ripley is the time equivalent of the chalk, occupying the same stratigraphic position, so that in reality the Selma Chalk might be considered a phase of the Ripley formation. The difference in the conditions of sedimentation are discussed in another part of this paper.

Westward from the meridian of Troy the formation consists of blue micaceous argillaceous sands, blue clays, glauconitic marls, and thin ledges of calcareous sandstone. Thick hard ledges of highly fossiliferous sandy marl are also present, a notable exposure being on the Jackson Highway, one-half mile southwest of Gastonburg, Dallas County. Excellent exposures of the Ripley occur in bluffs of the Alabama River north of Camden, Wilcox County and in the neighboring hills and on the Tombigbee River near Moscow, Sumter County.

Section of Ripley Formation, Alabama River.

Tertiary, Clayton Formation:	
9. Hard yellowish crystalline limestone with abundant *Turritella mortoni* (Turritella rock)	8 feet
Cretaceous, Ripley formation:	
8. Bluish micaceous argillaceous sand with fossils	35 feet
7. Bluish sandy clay	10 feet
6. Bluish sands, coarse grained	10 feet
5. Bluish massive argillaceous micaceous sands with frequent hard ledges of calcareous sandstone, from 2 inches to 2 feet in thickness	100 feet

4. Calcareous sandy clays of bluish color with shell casts in lower portion .... 25 feet
3. Bluish sandy clay and calcareous blue sands and sandy argillaceous highly fossiliferous limestone........ 30 feet
   The limestone thickens westward from Canton Landing (northwest of Camden) to at least 45 feet at Moscow Landing on the Tombigbee River.
2. Bluish fossiliferous sands containing thin ledges of hard highly fossiliferous calcareous sand. *Exogyra costata, Gryphaea vesicularis. Ostrea falcata* in sands........ 25-30 feet

Selma Chalk:
1. Selma Chalk
   Total thickness of Ripley marl........ 270 feet

The foregoing section, while approximately correct in general, does not attempt the detail of all the exposures studied. It is also possible that the total thickness given is somewhat less than the actual.

The blue sands and clays of the Ripley weather or oxidize into yellowish subsoils and generally black topsoils. The topography varies from very rough near the Alabama River, to more gently rolling and prairie-like away from the stream.

The most characteristic fossils are: *Ostrea falcata, Ostrea larva, Exogyra costata, Gryphaea vesicularis, Pecten quinquecostatus*, etc., etc.

At Troy, on the southern edge of the Ripley marl terrane, the formation has a thickness of nearly 450 feet, while at Union Springs the thickness of the Selma Chalk is 515 feet, giving a total of 965 feet for the two phases of the Ripley period sediments. Eastward of Troy and Union Springs, the Ripley increases in thickness, while the chalk decreases correspondingly until in Russell County and along the Chattahoochee River the chalk has disappeared entirely and the marl is about 950 feet in verical section. In character the materials along the Chattahoochee River resemble very closely those of the same formation along the Alabama River, but with fewer indurated sandy ledges so characteristic of the formation in the Bridgeport vicinity.

At the base of the Ripley on the Chattahoochee River there is a bed of calcareous sandy clay, having a thickness of about 125 feet. The remaining beds are gray to blue calcareous sands, yellowish cross-bedded sands, greenish glauconitic marls and a few indurated calcareous sand ledges. The strata are frequently fossiliferous. For a complete section along the Chattahoochee River, see section by Langdon (Figure 22).

The fossil content is quite similar to or identical with that of the combined Selma and Ripley in the western part of the strata, namely, *Exogyra costata,* (upper half on Chattahoochee River) *Exogyra ponderosa* (lower portion), *Gryphaea vesicularis, Ostrea larva, Plicatula urticosa,* Anomia sp., etc., etc.

The Ripley soils of the eastern part of the State are generally yellowish sandy with narrow strips of tough yellow prairie land derivative of calcareous clays of the formation. These clays resemble very closely the subsoil of the Selma Chalk. The topography of the Ripley is generally hilly near the drainage channels to rolling and flat away from the main streams. Where there are local developments of indurated ledges a rough country is resultant.

TERTIARY SYSTEM.

EOCENE.

Formations of Eocene age outcrop across the southern portion of Alabama in a belt some sixty miles wide on the Mississippi line and forty miles in width along the Chattahoochee River. The general direction of the belt is about North 15° West-South 15° East. The entire thickness of the series is nearly 1,000 feet in eastern Alabama and 1,600 to 1,800 feet in the Alabama River section and westward into Mississippi. Calcareous strata predominate at the base, cross-bedded and massive sands and laminated clays in the middle two-thirds, and calcareous strata in the upper one-fourth. The series has been divided into four groups and ten formations by E. A. Smith and others, each of which is distinctive in lithological character and to a lesser degree in fossil content. The materials are of both shallow marine and non-marine origin and show rather slight differences of conditions of sedimentation and a rather remarkable persistency in major characteristics from one side of the State to the other, considering the comparative thinness of the subdivisions. Excellent exposures of the strata are visible in the bluffs and the banks of the three major streams which traverse the outcrop of the series, namely: the Chattahoochee, Alabama, and Tombigbee Rivers. These river exposures together with outcrops along the tributaries in the immediate vicinity of the major streams, enable descriptions of the various beds of the formation almost foot by foot. These sections can be checked against various well logs to the point that one can feel reasonably certain of the accuracy of the resultant sections.

The reader is referred to the sections on Figures 22 and 23 for the broader characteristics while the formations are described in more or less detail on the next succeeding pages.

MIDWAY GROUP.

In the western and middle parts of Alabama the Midway Group has been subdivided into three formations: the Clayton limestone at the base and the Sucarnochee and Naheola formations above. The Ripley beds below the Midway are near shore deposits of argillaceous, calcareous sands while the Clayton limestone was deposited in somewhat deeper quiet waters. A slightly wavy line of contact with phosphatic nodules shows an unconformable relationship between the Cretaceous and Tertiary beds. In the eastern part of the State this unconformity is marked by a bed of very coarse-grained or conglomeratic sandstone. The data at hand are insufficient to determine the extent of the unconformity though it is evident that the time interval between the Cretaceous and Tertiary seas over the present area of contact was slight.

The type locality of the Midway is at Old Midway Landing, Wilcox County on the Alabama River where the Clayton limestone is exposed. The name "Midway" is rather unfortunate since the beds occur at the base of both the Tertiary system and the Eocene Series, which makes the name rather misleading, even though having been named for a locality and not intended to denote the stratigraphic position. Smith at one time proposed that the name be changed to Clayton since near the town of that name the lower limestones are well developed. It seems that this would be a very satisfactory designation.

CLAYTON LIMESTONE.

The thickness of the Clayton Formation or Clayton Limestone in the Alabama River area is about 25 feet with five to ten feet of dark yellow to brownish-semi-crystalline limestone at the base containing abundant *Turritella Mor-*

toni and Turritella humerosa from which the name "*Turritella* Rock" was derived. *Venericardia planicosta,* oyster shells and coral are likewise present. This bed is overlain by about 5 feet of calcareous sand which is in turn overlain by ten feet of limestone containing *Enclimatoceras Ulrichi,* White, from which the name "Nautilus Rock" was given to the limestone by Smith. The Turritella Rock is exposed as large boulders 3½ miles southwest of Minter on the Camden road, and the Nautilus Rock at the base of Grave Yard Hill, near Allenton, in Section 5, Township 11, Range 10 E., where the section has been described by E. A. Smith as follows:

Section from top of Grave Yard Hill to Pine Barren Creek.

Sucarnochee Formation .	
8. Grayish white, calcareous sand, with small phosphatic nodules, characterized by an abundance of crustacean remains	5 feet
7. Whitish, calcareous sands, with several ledges which shale off in weathering	20 feet
6. Hard, yellowish, sandy limestone, containing small phosphatic nodules. This is the rock which forms the walls around all the low hills in the vicinity	2 to 3 feet
5. Yellowish, calcareous, clay sand, with white lime concretions, becoming grayer in color and more clayey, and containing numerous fossils identical with those found at Black Bluff	15 feet
4. Black, calcareous clays, yellowish gray on weathered surfaces, also containing the Black Bluff fossils, but less abundantly than the preceding bed	20 feet or more
Clayton Formation.	
3. Hard grayish white limestone, characterized by great numbers of a large Nautilus (Enclimatoceras Ulrichi) and hence known as the Nautilus Rock	About 10 feet
2. Calcareous sands forming basis of the black, sandy prairies of this vicinity	6 feet
1. Hard, yellowish white, crystalline lime rock, sandy in places and filled with red specks, highly fossiliferous, containing Turritella in great numbers; also Carditas, a Rostellaria, Ostrea, and two or three species of coral. This is one of the most persistent of the Tertiary rocks towards the east (Base of Tertiary)	8 feet

West of the Alabama River, the Clayton limestone has been traced as far as the Tombigbee River. Eastward of the Alabama River the Clayton limestone increases in thickness, reaching a maximum of 200 feet on the Chattahoochee River below which there is an 18-foot bed of sandstone and conglomerate that is likewise referable to the Clayton Formation and marks the unconformable contact with the underlying Cretaceous.

Langdon (Figure 22 and page 5) measured 200 feet of soft white calcareous sand and argillaceous limestone along the Chattahoochee. A well-defined unconformity between the Clayton limestone and the overlying Wilcox strata is well displayed in the river bluff at Fort Gaines, Georgia, and at Brown's Mill on Cemochechobee Creek, one and one-half miles north of Fort Gaines. At this exposure there are frequent "pot holes" in the limestone ten to fifteen feet deep, filled with Wilcox materials. Eastward from this exposure the limestone is a hard pinkish variety with rather abundant fossils. Some of the Clayton fossils in eastern Alabama and western Georgia are *Ostrea pulaskensis, Ostrea crenulimarginata, Turritella mortoni* and *T. humerosa.*

SUCARNOCHEE FORMATION.

The Sucarnochee formation was named by Smith for Sucarnochee Creek in Sumter County where the beds are well exposed. At Black Bluff on the Tombigbee River he has described the following section:

3. Yellowish clay, which makes the basis of the Flatwoods, occupying top of bluff	about 20 to 25 feet
2. Black, slaty clay, fossiliferous	40 feet
1. Brownish shale or clay to water level	8 to 10 feet

The total thickness of the black clays of the Sucarnochee make up the lower 30 feet of the formation while the remaining 70 to 80 feet are composed of calcareous sands and clays, shales and sandy limestones. The section on page 145 describes the lower 65 feet of the formation while 25 feet of sandy limestone, shale and glauconitic calcareous sands complete the section as described near Oak Hill.

No exposures of the Sucarnochee were recognized along the Alabama but from the general dip of the Clayton and Naheola beds and the interval between these formations, the Sucarnochee has a thickness of from 110 to 120 feet. It is the basis of the Postoak Flatwoods described under "Topography."

The formation disappears or merges into the Clayton limestone between the Alabama and the Chattahoochee Rivers, probably in Butler or Crenshaw Counties.

NAHEOLA FORMATION.

Next overlying the Sucarnochee clays are some 150 feet of fossiliferous marls and alternating 10 to 20-foot beds of sandy laminated clays and cross-bedded sands. At Matthews Landing on the Alabama River the Marl is exposed as follows:

3. Bluish to micaceous sandy marl with abundant fossils	5 feet
2. Dark grayish micaceous sandy marl with same fossils as bed 3 but less abundant and huge round concretionary boulders	4 feet
1. Black micaceous sandy marl with fewer fossils than either beds 2 or 3. Gastropods predominate	7 feet

A fault with a displacement of four feet was seen near the lower end of the bluff. The strata dip not more than 20 to 25 feet per mile southward. For about one mile below the bluff slight undulations in the strata are evident from the positions of the marl bed.

From Clifton Ferry downstream to Coal Bluff there are almost continuous exposures of alternating 10 to 20-foot beds of greennish laminated clay, laminated sands and cross-bedded sand. The laminated sand strata contain frequent large rounded concretionary calcareous sandstone boulders, similar to those at Matthews Landing but without fossils. These clay and sand beds are occasionally discontinuous or merge rapidly from one to the other. Slight undulations are evident in a number of places while at Clifton Ferry three faults with very little displacement were seen.

Some of the most characteristic Naheola fossils are as follows: *Voluta showalteri, Rostellaria velata* (very abundant), *Venericardia rotunda, Venericardia sillimani, Turritella mortoni, Turritella alabamensis, Leda eborea, Pseudoliva* sps,, *Natica,* sps., etc., etc.

The Tombigbee River exposures are quite similar to those on the Alabama with the same characteristic fossil and lithologic features. Eastward from the Alabama River the Naheola disappears as does the Sucarnochee.

In wells drilled for water and oil in the south-central and southwestern parts of the State, clay and shale strata were encountered in the entire stratigraphic position of the Midway. No differentiation of the three formations can be made from the logs, because of the similarity of the strata as reported. This seaward transition from near shore sands and clays to more coherent deeper water clays and shale is the natural resultant of a normal condition of deposition. The shales and "gumbos" are reported in the logs to be gray to blackish. See log of Mitchell No. 1, page 204.

WILCOX GROUP.

The next series of beds, stratigraphically above the Midway, has been named the Wilcox Group from the typical exposures of the strata in Wilcox County along the Alabama River. This group and formation name have been extended to include all of the strata of the Alabama Wilcox horizon from Georgia into Texas.

In Eastern Alabama the conditions of sedimentation in Midway and Wilcox times were somewhat different, the former are primarily limestones and calcareous sands, while the latter, Wilcox, are near shore marine and fresh water laminated clays and sands and cross-bedded sands. The lithologic and paleontologic characteristics of the Wilcox obtains across the entire State while the thickness diminishes to the eastward. The group has been subdivided by Smith into four formations: the Nanafalia, at the base; and the Tuscahoma, Bashi and Hatchetigbee formations upward in the order named. Each of these formations has very distinctive characteristics which are described briefly on succeeding pages. A more or less complete succession of the beds along both the Chattahoochee and Alabama Rivers is given in Figures 22 and 23, while the vertical section in Clarke County is shown in the record of the Bollinger No. 1 well. An unconformity is evident between the Midway and Wilcox beds in Eastern Alabama and quite probable in the western part of the State though not definitely recognized.

NANAFALIA FORMATION.

The Nanafalia formation, the lower-most of the Wilcox Group, consists of from 125 to 150 feet in ascending order of lignite, massive and laminated sands and clays, cross-bedded sands, highly fossiliferous greesand marl and kaolin-like laminated to thick-bedded clays, with thin, highly fossiliferous indurated beds. The formation is readily subdivided into three lesser divisions based on both lithology and fossil content. In order to assist in the description of certain features concerning the formation, the lower of the three phases will be referred to as the Coal Bluff beds while the two upper phases will be referred to as the Gullette Bluff beds, where their entire thickness is well exposed. Smith has used the term "Coal Bluff" to apply to the lignite at the base of Nanafalia. In this paper the name is extended to include all the strata below the Gullette Bluff fossiliferous marl.

The Coal Bluff beds consist of 2 to 7 feet of lignite at the base overlain by 40 to 70 feet of cross-bedded sands, laminated clays and sandy clays with sand lenses and at the top a 20-foot bed of yellow to clean white cross-bedded sands with a few tough blue clay streaks and lenses or flattened pebbles. The best development of these beds is in Wilcox County. Westward in Marengo they have a 60-foot thickness while on the Chattahoochee River according to Langdon's Section they are entirely absent.

The following section is descriptive of the Gullette Bluff and Coal Bluff in Wilcox County:

Composite Section of Nanafalia Formation in Wilcox County.
Black's Bluff, Alabama River.

27.	Lafayette sands and gravel	25 feet
26.	Blue laminated, jointed clay weathering to tough yellow clay	42 feet
25.	Hard calcareous fossiliferous sandy claystone with fossils	2 feet
24.	Blue, laminated to jointed clay, cream colored on dry exposure	6 feet
23.	Sandy fossiliferous calcareous claystone	5 feet
22.	Blue kaolin-like clay, conchoidal fracture	25 feet
21.	Hard, glauconitic calcareous claystone with fossils	3 feet
20.	Blue joint clay with a few sandy layers	6 feet
19.	As bed 21	2 feet
18.	As bed 22	10 feet
17.	Hard sandy bed with high percentage of glauconitic oxidizing to limonite	6 feet
16.	Unconsolidated white to yellow sand (seen only at Black Bluff)	5 feet
15.	Laminated sand and clay	9 feet

Grampian Hills, 2 miles southeast of Camden.

14.	Hard highly fossiliferous glauconitic clay. Upper limit of *Gryphaea thirsae*	2 feet
13.	Glauconitic sandy marl with large numbers of *Gryphaea thirsae*	8 feet
12.	Laminated sandy clay, blue	5 feet
11.	Glauconitic *Gryphaea thirsae* marl	30 feet
10.	Glauconitic sand, no fossils	3 feet
9.	White to yellow cross-bedded massive sands with blue clay lenses	20 feet

Section above Gullette Bluff on Gravel Creek and Alabama River.

8.	Black laminated carbonaceous clay	5 feet
7.	Unconsolidated sand with boulders	8 feet
6.	Black laminated clay	8 feet

5. Unconsolidated sand and boulders, glauconitic	8 feet
4. Black laminated clays	10 feet
3. Sand with boulders and hard ledges	15 feet
2. Lignite	4 feet
1. Lignitic shale	2½ feet
Total thickness of Nanafalia	250 feet

Beds one to nine of the above section are exposed in a series of bluffs along the Alabama River from Coal Bluff to Gullette Bluff and on Gravel Creek near the crossing of the Camden-Nellie road. The section can not be measured as closely as desired but the data as recorded are probably a very close approximation to the actual condition. The strata of beds 10 to 26, inclusive, are excellently exposed in a number of localities and very close measurements can be readily made. The exposure selected for the stratigraphic succession given in the section is in the Grampian Hills, two miles southeast of Camden, on the Camden-Fatama road. Quite a number of vertical-faced gullies display perfect sections of the sand bed below the marl and the lower twenty or thirty feet of the marl. The next succeeding strata are well exposed in a road cut on the northern scarp of the Grampian Hills on the Fatama road. The exposure of the upper clays of the Nanafalia formation selected for the section is in the old road down Black's Bluff to the landing on the Alabama River, one mile below Gullette Bluff. The Gullette Bluff beds here have a thickness of 170 feet, while the exposed thickness at Gullette Bluff is 168 feet, and along the Camden-Nellie road up the hill south of Gravel Creek the thickness is about 175 feet. In each case Lafayette sand and gravel overlie the clay so it is possible that the maximum thickness is somewhat more than that exposed.

The Nanafalia section as exposed in Marengo County on the Linden-Nanafalia road shows the formation to be somewhat thinner than on the Alabama River. The following section was observed on Geneva Hill one-fourth mile south of Nolan's store, Section 23, Township 14, Range 1 East.

Geneva Hill Section, Marengo County.

7. Massive greenish sand with glauconitic, clear, quartz sand, and blacksand; lies unconformably on next bed below	20 feet
6. White, massive, to cross-bedded white and yellow sands, black sand streaks	15 feet
5. Laminated to jointed bluish clay (weathers cream colored) with two 18-inch beds of hard, sandy fossiliferous clay-	

stone. Fossils: *Turritella mortoni* (large), *Venericardia planicosta*, *Gryphaea thirsae* (comparatively few) ....30 feet
4. Greensand marl with *Gryphaea thirsae* in large numbers ....20 feet
3. Clayey glauconitic sand similar to marl but without fossils; large round concretionary boulders at the base .... 6 feet
2. Gray laminated clay with some sand and glauconite .... 4 feet
1. White cross-bedded sand, grading into yellow at base; gray clay pebbles and lenses frequent ....20 feet

Lignite outcrops about 65 feet below base of bed No. 2. With Naheola clayey sands exposed in creek bank 85 feet below.

From the above the Coal Bluff Beds have an apparent thickness of about 70 feet while the overlying Gullette Bluff beds have a thickness of about 60 feet (beds 2 to 5, inclusive). Overlying the Nanafalia is a 15-foot bed of sand which is apparently the lowest member of the Tuscahoma formation. Three miles south of this exposure the sand has a thickness of 35 feet with the 20 feet of greenish sand above. There are no fossils in the two beds overlying the Nanafalia clays but from the lithologic character of the material of these and the strata succeeding above, they are referable to the Tuscahoma formation. This section shows the Nanafalia to have a total thickness of about 130 feet which is very close to the exact thickness, though the Coal Bluff beds were not seen in complete section. Where exposures were visible the character of the materials seems to be the characteristic laminated and carbonaceous clays and cross-bedded glauconitic sands. Smith described several exposures on the Tombigbee River of characteristic Nanafalia beds with a hiatus of 16 feet at the top and an eighteen foot hiatus in the *Gryphaea thirsae* greensand marl proper. He estimates the total thickness of the Nanafalia to be 200 feet with 100 feet of strata exposed above the base of the marl bed. A considerable thinning of the Nanafalia between the Alabama and Tombigbee rivers is evidenced by the section obtained along the Rembert-Nanafalia road.

Along the Chattahoochee River Langdon describes a section of 175 feet of Nanafalia marls, lithologically and paleontologically similar to the marls and overlying clays in the Alabama River section. The Coal Bluff beds seem to be missing in East Alabama. The succession of strata is shown in Langdon's Section (Figure 22) and pages 216 to 220.

The Nanafalia formation is well exposed on steep north-facing scarps, across Marengo and Wilcox Counties, which frequently attain an elevation of 200 feet above the drainage levels. The supporting mediums of these ridges are the indurated beds in the upper portion of the formation. The gentle dip slopes to the southward together with steep north slopes, form cuestas in their general aspect. Two of the typical Nanafalia cuestas compose the Grampian Hills in Wilcox County and the hills to the south of Beaver Creek in Marengo County.

The characteristic fossils of the Nanafalia are *Gryphaea thirsae* in great abundance and *Ostrea compressirostra* in the glauconitic marls, and a few *Gryphaea thirsae,* abundant *Turritella mortoni* and *Venericardia planicosta* in the indurated beds in the upper clays and sandy clays. The Coal Bluff beds at the base contain no fossils. These very definite characteristics, both lithologic and paleontologic, of the Nanafalia formation, make it an excellent key horizon for structural and stratigraphic determinations in the Eocene formations across the entire State. Eastward of Butler County to the Chattahoochee River the typical greensand marls disappear, being replaced by the clays, sandy clays and siliceous claystones similar to the upper part of the West Alabama sections.

TUSCAHOMA FORMATION.

Next above the Nanafalia Formation is the Tuscahoma or Bell's Landing Formation, which consists of 150 to 200 feet of sands, sandy clays, laminated clays and fossiliferous greensand marls. Eastward from Wilcox County this formation gives rise to a rather flat monotonous country with few exposures of unweathered beds except along the major streams. Low bluffs on the Pea River near Elba exhibit rather poor exposures of unfossiliferous sandy clays, while Langdon considered 145 feet of gray sandy clays, interstratified with red sands and gray laminated sandy clays, exposed in bluffs along Choctawhatchie River near the Abbeville-Clayton road, 6 miles from Abbeville, Henry County, probably referable to the Tuscahoma. On the Chattahoochee River, beginning four miles south of Fort Gaines, Georgia, and continuing ten miles down stream, Langdon measured 170 feet of "Light yellow and gray sandy clays with round boulders in the sandier portion" which he correlates with the Bell's Landing and Lower Peach Tree exposures of the Tuscahoma.

At Yellow Bluff and Lower Peach Tree on the Alabama River the following section was obtained:

Composite section of exposures along Alabama River from Bell's Landing to a point 2 miles above Yellow Bluff.

Hatchetigbee Formation:		
14.	Yellow sandy laminated clays with thin layers of kaolin-like clay and thin sand strata. Dark yellow streaks cross the strata evidently from oxidized glauconite. Aneroid measurement	120 feet
Bashi Formation:		
13.	Highly fossiliferous greensand marl with large, very hard calcareous sandstone boulders with the same fossils as matrix	6 feet
12.	Green sandy clays and unconsolidated sand, cross-bedded in part, at base; beds of lignite	50 feet
11.	Cross-bedded argillaceous glauconitic sands	20 feet
10.	Lignite (Smith, covered at time of writer's visit)	2½ feet
Tuscahoma Formation:		
9.	Laminated sandy clays slightly cross-bedded	12 feet
8.	Unconsolidated cross-bedded greenish gray sand	12 feet
7.	Blue laminated to thin bedded clay with several 2 to 3-inch sand layers. This bed is exposed along river at waters edge to near Bethel Fault one and one-half miles up stream	20 feet
6.	Highly fossiliferous glauconitic sandy marl with large concretionary boulders. Large *Voluta newcombiana* typical), *Turritella mortoni*, *Rostellaria trinodifera*, *Protocardia niccoletti*, etc. in lower part with *Venericardia planicosta*, *Ostrea compressirostra*, etc. in upper portion	6 to 10 feet
5.	Alternating layers 4 to 6 inches thick of glauconitic sand and sandy laminated clay (only upper 10 feet well exposed)	25 feet
4.	Bluish sandy clay marl with fossils	5 feet
3.	Gray sandy laminated clays	50 feet
2.	Greensand with fossils (Smith)	1 foot
1.	Gray sandy clays to water (Smith)	10 feet

Beds 1 to 7 inclusive exposed at Lower Peach Tree, beds 6 to 14 inclusive exposed at Yellow Bluff. Other exposures of Tuscahoma and Bashi beds occur in the banks of the Alabama from Yellow Bluff down to Johnson's Wood Yard Landing.

The actual contact of the Nanafalia and Tuscahoma formations has not been described along either the Alabama or Chattahoochee Rivers but what appears to be the contact was seen by the writer at three localities in Marengo County. On Geneva Hill, 8 miles southeast of Rembert on the Rembert-Nanafalia road, the Nanafalia is overlain for 20 feet of unconsolidated massive to cross-bedded white to banded yellow sands with a few streaks of black sand. Above this are 18 feet of massive greenish argillaceous sand which is in turn overlain by Lafayette sand and gravel. On the scarp south of Double Creek and 2½ miles north of Nanafalia 55 feet of Nanafalia marl are overlain by 35 feet of white to yellow massive and cross-bedded sand above which are 20 feet of massive greenish sand with Lafayette sand and gravel covering. In the scarp south of Sweetwater Creek and one mile south of the village of Sweetwater a 40-foot bed of white to yellow sand immediately overlies the Nanafalia with greenish sand next above for 20 feet, and laminated sand clay following. The last mentioned bed is the typical material of this formation in other localities. Thus at least 25 to 40 feet of clean white to yellow sand should be added to the base of the Lower Peach Tree bed in order to complete the section. It is possible that a small thickness of other strata is missing but certainly very little.

Good exposures of strata that evidently belong to the Tuscahoma formation are exposed in road cuts on the hill south of Horse Creek, one mile north of Putnam. The section here includes 160 feet of strata which, with the 45 to 65 feet of beds near Geneva and south of Sweetwater, probably include all of the Tuscahoma. Southward from Geneva Hill to Nanafalia the white sand bed and the overlying greenish sand and sandy clay seem to be either flat or slightly folded. Certainly the normal south dip does not prevail. It appears that in a distance of nine miles south from Geneva Hill the two lowest Tuscahoma beds have just dipped below the surface. Southward from Putnam the Tuscahoma strata dip probably at a rate less than normal and finally go beneath the Bashi strata in the scarp south of Bashi Creek, 8 miles south of Horse Creek.

Thus we have in the sections along the Alabama River a total of 145 feet of strata which, with the lower beds overlying the Nanafalia in Marengo County, gave a total thickness of approximately 200 feet. If the Geneva Hills and Sweetwater sands are classed with the Nanafalia formation it will then have a thickness of 150 to 170 feet in Marengo County and the Tuscahoma 160 to 175 feet, which more nearly agrees with the Alabama and Tombigbee River sections.

The characteristic fossils of the Bell's Landing marl which, about 42 feet below the top of the Tuscahoma, are very large *Venericardia planicosta* (four inches in diameter) and *Voluta newcombiana* about four inches long and one and one-half inches in diameter. *Rostellaria trinodifera* and many others are also present in the Bell's Landing and lower marls.

BASHI FORMATION.

The Bashi Formation, named by Smith for Bashi Creek, tributary to the Tombigbee River, is the next group of beds in stratigraphic succession above the Tuscahoma Formation. The Bashi consists of a six-foot fossiliferous greensand marl bed containing large concretionary boulders of calcareous sandstone underlain by about seventy feet of gray sandy clays, unconsolidated sands and cross-bedded glauconitic sands with several thin lignite beds in the middle part, and a two to three-foot stratum at the base. The total thickness is from 75 to 80 feet, the complete succession being exposed in Yellow Bluff on the Alabama River and are described in the composite section on page 153. These strata are also exposed three to six miles below Bell's Landing on the Alabama River, on the Tombigbee River at Wood's Bluff and in the bluffs along Bashi Creek in northern Clarke County. Some 45 feet of strata which Langdon refers to the Bashi, outcrop along the Chattahoochee River; see Chattahoochee River section by Landon.

Aldrich has recognized about one hundred species in the Bashi among which are *Pseudoliva vetusta, Dentalium microstria, Venericardia planicosta, Leda protexta, Protocardia nicoletti and Nucula ovula.* Sharks' teeth are also present.

HATCHETIGBEE FORMATION.

The Hatchetigbee Formation lying next above the Bashi was named by Smith for a bluff of that name on Tombigbee River. He includes all the strata between the case of the Claiborne and the Bashi marl in this series of beds, which is given a thickness of 170 to 175 feet along the Tombigbee River. On the Alabama River the formation is apparently somewhat thinner, probably 150 to 160 feet. At Johnson's Landing, six miles below Bell's Landing, the Bashi formation dips below the river. At Welch's Bluff, three and one-half miles down the dip from Johnson's Landing 100 feet of Hatchetigbee strata are exposed. Based on a dip of thirty feet per mile there would be 50 to 60 feet of Hatchetigbee beds below the water level at Welch's Bluff giving a total thickness of 150 to 160 feet. These strata are poorly exposed at Yellow Bluff.

Section of Hatchetigbee Strata at Welch's and Yellow Bluffs, Alabama River and L. & N. Tunnel, Monroe County.

13.	Bluish green clay along undulating surface of bed below. Lignitic pebbles and lignitic clay marks slight unconformity between Claiborne and Wilcox	2 inches
12.	Bluish green compact very sandy clay	2½ feet
11.	Bluish green compact clay with clear quartz grains	½ foot
10.	Blue Laminated clay, carbonaceous	17 feet
9.	Highly fossiliferous greensand marl. Fossils well developed	1 foot
8.	Blue laminated clay	8 feet
7.	Fossiliferous greensand marl. Fossils very numerous in upper five feet: *Venericardi planicosta. Leda protexta, Corbula nasuta, Ostrea* similar to *Ostrea vicksburgensis, Turritella carinata, Dentalium,* sharks' teeth, etc.	12 feet
6.	Blue laminated clay, slightly sandy in streaks	20 feet
5.	Highly fossiliferous glauconitic sandy marl. Indurated boulders. Fossils similar to bed 7 but smaller	6 feet
4.	Gray to blue laminated sandy clay	20 feet
3.	Lignite	1 foot
2.	Laminated, sandy, glauconitic clay with boulders at water's edge	15 feet
1.	Gray to blue laminated clays, sandy clays and clay	50-55 feet

Bed No. 1 exposed in Yellow Bluff, beds 2 to 10 inclusive exposed in Welch's Bluff and beds 11 to 13 inclusive exposed at north end of L. & N. Tunnel, Monroe County.

Smith* has described sections on the Tombigbee River at Hatchetigbee, White's Bluff, Davis Bluff and McCarthy's Ferry that are entirely similar to the section given above, but totaling 170 to 175 feet. Langdon' describes thirty feet of "gray sands interlaminated with light colored sandy clays" below Claiborne Buhrstone on Persimmon Creek, 4 miles south of Georgiana, which is correlated with the Hatchetigbee. He also describes 50 feet of sands and sandy clays below the Claiborne Buhrstone in Section 17, Township 7, Range 15 East, Butler County and thirteen feet of sands at Abbeville as being in the Hatchetigbee. On the Chattahoochee River Langdon found only ten feet of gray lignitic sandy clay at the mouth of Yantayabba Creek, which he considered to be the Hatchetigbee.

Thus we find that the Hatchetigbee Formation reaches its greatest development in the western part of the State and gradually thins to ten feet or more on the Chattahoochee River. The belt of outcrop of the beds has no particular topographic characteristics being generally a rolling to rather flat, monotonous country.

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*"Geology of the Coastal Plain of Alabama," Smith, Johnson and Langdon, Alabama Geological Survey, 1894.

CLAIBORNE GROUP.

The Claiborne Group of formations in Alabama, which immediately overlies the Wilcox Group, has been subdivided into three formations, from the upper down, as follows:

3. *Gosport Greensand;* fossiliferous sands.
2. *Lisbon Formations;* calcareous fossiliferous sands and fossiliferous greensand marls.
1. *Tallahatta Buhrstone;* soft greenish (white to yellow when oxidized and dry) siliceous claystone with frequent hard ledges in upper portion. The hard silicified ledges are highly fossiliferous while the claystone has scattering fossils.

The Claiborne beds cross the entire State from Henry County on the Chattahoochee River to Choctaw County on the Mississippi line, coming to the surface in a belt from eight to eighteen miles in width, reaching the maximum in Henry, Conecuh and Washington Counties. The Hatchetigbee anticline in Clarke, Choctaw and Washington Counties is encircled by a belt of Claiborne not connected with the main belt of outcrop while an inlier of Claiborne occurs around the town of Geneva in Geneva County.

From Conecuh County westward into Mississippi the surface terrane of the Claiborne is characterized by a very rugged topography caused by the resistance to weathering and erosion of the indurated ledges in the Tallahatta Buhrstone. The hills frequently reach a height of 300 to 400 feet above the main drainage levels and form, in the broader interpretation, cuestas with a very abrupt scarp on the north side and long gentle dip slopes to the southward. This dip-slope plain has in most cases been rather highly dissected by southward flowing streams. These topographic features have formed many excellent exposures of the strata. Eastward from Conecuh County the Claiborne terrane lacks distinctive topographic features being primarily flat to rolling land with the only exposures in road and railroad cuts and along the stream channels.

TALLAHATTA BUHRSTONE.

The Tallahatta Buhrstone, originally called "Buhrstone" by Tuomey and later "Tallahatta Buhrstone" by Smith, lies directly in the Hatchetigbee formation of the Wilcox Group with possibly a very slight unconformity between as indicated by the wavy line of contact and the lignitic pebbles in the exposure at the L. & N. tunnel, Monroe County. The beds are composed of greenish, siliceous claystones with frequent thin fossiliferous calcedonized strata in the upper portion. Dr. Smith* has recognized a thickness of about 300 feet along the Tombigbee River, while the writer obtained a section of 150-155 feet on the Alabama River computed from actual exposures and measured dips. At Welch's Bluff the base of the Tallahatta is 100 feet above mean low water and at Lisbon Bluff the top is 10 feet above water; the distance between the two bluffs being about 8 miles across the strike of the beds. The measured dip is 30 feet per mile, which was checked by exposures in several bluffs between. The following section is roughly descriptive of the strata.

Section of Tallahatta Buhrstone on Alabama River from Welch's Bluff to Lisbon Bluff.

7. Lisbon formation.	
6. Bluish clay with rope-like concretions of clayey sandstone. Placed by Smith at top of Tallahatta (Lisbon Bluff)	12 feet
Bluff at mouth of Silver Creek:	
5. Exposure covered, boulders hard claystone and silicified fossiliferous rock	30 feet
4. Claystone (greenish when unoxidized and wet, white on dry exposures) with some glauconitic and a very hard ledge	10 feet
3. Ledge of calcedonized fossiliferous stone	1-2 feet
Welch's Bluff.	
2. Indurated thick-bedded claystone, cream colored, a few fossils	20 feet
1. White (weathered, dry) claystone with parallel to conchoidal fracture, generally banded with yellow. A few hard fossiliferous ledges	80 feet
Total thickness of Tallahatta	154 feet
Hatchetigbee below.	

At Welch's Bluff the exposure is in a vertical bluff that prevents a close examination. An excellent section of the Tallahatta that may be examined in detail showing the lower 108 feet of the strata are exposed at the north mouth of the L. & N. tunnel in northern Monroe County. Other excellent exposures occur throughout the belt in Monroe and Clarke Counties. The claystones are generally glauconitic and frequently sandy with hard, irregular ledges occurring at intervals of 10 to 20 feet. On a fresh unweathered surface they are always a light greenish color, which changes to a white or cream color with yellow band-ing on oxidation. The hill slopes where clean exposures are covered by wash are practically always littered with fragments and large boulders of the claystone and boulders of the calcedonized fossiliferous rock. The materials weather to a tough yellow clay soil quite similar in appearance to the soil derivative of the upper clays of the Nanafalia formation. In fact the Claystone of the Tallahatta is quite similar in general appearance to the more indurated clays of the upper Nanafalia but not readily mistakable.

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*Smith, Eugene A., op. cit.

Hopkins* estimated the thickness of the Tallahatta to be about 200 feet on the northern slope of the Hatchetigbee anticline and 20 feet near the Lower Salts Works on the Tombigbee River, Washington County. This considerable thinning to the southward is evidently related to the formation of the anticline.

Dr. Smith† has described sections of the Tallahatta Buhrstone on the Tombigbee River at McCarthy's Ferry, where he recognized 250-270 feet, at White Bluff, where he found 115 feet, and at Hatchetigbee Bluff, where the upper 20 to 30 feet are Tallahatta.

Eastward from Conecuh County to the Chattahoochee River the Buhrstone seems to lose its most distinguishing features and is interbedded with strata resembling the Lisbon formation on the Alabama River. Langdon's section is descriptive of the occurrence on the Chattahoochee River (see page 220).

While there appears to be a very slight unconformity between the Hatchetigbee and the Tallahatta formations, there was at the same time a gradual transition from the lower formation to the upper separated by a short period of shallow water as evidenced by the sandy character of the upper three feet of the Hatchetigbee formation and the sand bed at the base of the Tallahatta as seen at the L. & N. tunnel. The wavy top of the Hatchetigbee, together with the lignitic pebbles possibly originated in a short time interval of very shallow water rather than from dry land erosion.

LISBON FORMATION.

The Lisbon formation though apparently merging with the Tallahatta Buhrstone to some extent in eastern Alabama, persists across the entire State as a distinct lithologic unit composed of calcareous sands, clays and glauconitic sands containing abundant fossils, the most prominent of which is *Ostrea sellaeformis*. The thickness of the unit is about 140 feet on the Alabama River. The section on the Tombigbee is incomplete though Hopkins* intimates a thickness of 200 feet for the Gosport and Lisbon combined on the north side of the Hatchetigbee anticline and 40 feet on the south side. On the Chattahoochee River Langdon refers 60 to 75 feet of strata to the Lisbon, while in the strata which he refers to the Buhrstone, there is considerable material entirely similar to the Lisbon.

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*Hopkins, Oliver B., Oil and Gas Possibilities of the Hatchetigbee Anticline, Alabama. U. S. G. S. Bull. 661-H, 1917, page 291.

†Smith, E. A., op. cit., p. 143.

The following section by E. A. Smith and L. C. Johnson† and checked by the writer, is descriptive of the complete section of Lisbon and Gosport:

Section of Claiborne and Lisbon Bluffs.

20.	Red loam, sand and pebbles	35-40 feet
19.	Argillaceous limestone, with greenish grains	45 feet
18.	Indurated ledge, with *Scutella lyelli*	3 feet
17.	Coarse, ferruginous sand, calcareous below; indurated ledge at base	6 feet
16.	Claiborne fossiliferous sands; ferruginous, with shells; laminated lignitic clays, with leaf impressions, and thin seams of lignite in places in upper part	15-17 feet
15.	Bluish green, glauconitic sandy marl, containing *Ostrea sellaeformis*, in part indurated	3-4 feet
14.	Calcareous, bluish gray clay, with a few badly preserved fossils, passing downward into a greenish, glauconitic sandy marl, containing great numbers of young shells of *Ostrea sellaeformis* and a few *Pectens*, the two together, clay and sand	18 feet
13.	Light gray, calcareous clay, similar to the preceding, with hard ledges at top and bottom, in all	About 7 feet
12.	Light yellowish gray, calcareous sands, with *Pectens* and *Ostrea sellaeformis*, the lower half indurated, containing casts of univalve shells	About 5 feet
11.	Light yellowish gray, calcareous sands, with thin beds of more clayey texture and with five or six hard, sandy ledges at intervals; the sand is, in places, loose and crumbling, and quite fossiliferous, with *Ostrea sellaeformis*, *Pecten deshayesii*, fragments of *Scutella lyelli*, etc. Lower 8 feet a bluish, clayey sand	About 27 feet
10.	Bed of greensand, with perfect shells and fragments of *Ostrea sellaeformis*, etc.	About 3 feet
9.	Dark blue, nearly black, sandy clay	2 feet
8.	Bluish green, clayey sands, few fossils above, but highly fossiliferous below and rather more clayey, *Venericardia planicosta*, *Nucula magnifica*, *Ostrea sellaeformis*, *Arca*	

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*Hopkins, O. B., op. cit.

†Op. cit., pp. 708-709, Geology of the Costal Plain of Alabama.

rhomboidella, Voluta sayana, Turritella mortoni, Turritella bellifera, etc. ....10 feet
7. Dark grayish blue greensand, peculiar small form of *Venericardia planicosta,* large *Turritella mortoni,* etc., 6 feet at Claiborne but 10 feet at Lisbon....
6. Hard, sandy ledge....8 inches
5. Calcareous, clayey sands, light yellowish to white color.... 8 feet
4. Coarse, ferruginous sands, with numerous fossils.... 3 feet
3. Light yellow sand, capped with a hard ledge, forming perpendicular bluff....15 feet
2. Blue, glauconitic sands, probably a modification of 18.... 5 feet
1. Bluish black clay; top of Buhrstone contains curious concretions of sandy clay, like interlacing roots....

Other exposures of Lisbon and Gosport beds occur at Coffeeville Landing, Tombigbee River, four miles west of Gilbertown, Section 33, Township 11 N., Range 4 W., and near Oven Bluff, Tombigbee River. Exposures of the upper Lisbon beds also occur on Choctawhatchee River near Geneva.

GOSPORT GREENSAND.

The Gosport greensand was so named by Dr. Eugene A. Smith from the type locality at Gosport Landing, five miles below Claiborne on the Alabama River. The most characteristic feature of this bed is the abundant beautifully preserved fossils which it carries among which are *Cytherea aequorea* in great numbers in the upper portion, *Pectunculus broderipii,* Lea, *Rostellari velata,* Conrad, *Voluta defranckii,* etc., etc. The fossil bed has been traced through Washington, Choctaw, Clarke and Monroe Counties, but does not seem to be present out of this area. The stratigraphic position of the Gosport is shown in the Claiborne section.

JACKSON FORMATION.

The "White Limestone" of Tuomey and of Smith included all of the limestone of Upper Eocene and Oligocene age which are now divided into the Jackson Formation at the base, the Vicksburg Group in the center, and the Salt Mountain or Coral Limestone at the top. The lowermost of the three is the upper formation of Eocene age while the upper two are lower Oligocene. Smith included the three formations under one group because of the lithologic and paleontologic similarity of the entire section of strata though he at the same time recognized the presence of the Jackson and Vicksburg formations of Hilgard and considered the Salt Mountain Formation as a distinct unit. Cooke* has made a study of the Jackson and Vicksburg from Mississippi across Alabama to Florida and Georgia and has made a somewhat closer subdivision of the strata. Hopkins† has also made a study of the Jackson and other St. Stephens strata in Clarke, Choctaw and Washington Counties, surrounding the Hatchetigbee Anticline.

The Jackson formation (Ocala formation of Cooke) of central Georgia‡ consists of 40 to 50 feet of soft white Bryozoan limestone containing a variety of fossils most typical of which are *Pecten perplanus, Orbitoides mantelli* and *Periarchus pileus-sinensis* (*Scutella lyelli*). Lying over the soft Bryozoan limestone is a six-inch to two-foot bed of hard semi-crystalline highly fossiliferous limestone which is in turn overlain by 50 feet, more or less, of Fuller's earth which, going down the dip of the strata, increases in calcareousness until it has become an argillaceous limestone in the area near Albany, Georgia. Southwestward from Albany to Saffold a few exposures occur in Calhoun and Early Counties near Arlington that are probably referable to the Jackson. A test hole here found a thickness of 60 feet of rather hard, massive, granular white limestone with a few poorly preserved fossils. Southwestward to the Alabama line no further exposures have been found. On Chattahoochee River, 2 miles below Gordon, Langdon describes 25 to 30 feet of weathered material containing numerous *Periarchus pileus-sinensis* (?), *Pecten nuperus*, etc. This strata evidently belongs to the Jackson. It seems that there might easily be a somewhat greater thickness here than has been described since the exposures are not particularly good.

Westward into Alabama the character of the Jackson changes to a series of less calcareous beds as indicated by the following section which is evidently referable to the Jackson:

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*Cooke, C. W., "The Age of the Ocala Limestone," U. S. G. S., Prof. Paper 95-I, pp. 114-117.

†Hopkins, Oliver B., op. cit.

‡Brantly, J. E., "Limestones and Marls of the Coastal Plain of Georgia," Georgia Geological Survey, Bull. 21.

Section 10 miles northeast of Geneva, Alabama, Section 19 or 20, Township 2, Range 23 East.

8.	Yellow and blue argillaceous sand which weathers to a deep red	20-30 feet
7.	Coarse red sands with abundant *Pecten perplanus*	2 feet
6.	Smooth greenish Fuller's earth-like clay	3 feet
5.	Bluish clay with streaks and pockets of glauconitic and silicified fossils	2 feet
4.	Calcareous glauconitic sandstone	3 feet
3.	Yellowish glauconitic sand packed with fossils, *Pecten perplanus, a small Ostrea* (*sellaeformis*? young) and *Orbitoides*	3 feet
2.	Soft cream colored sandy limestone with great numbers of small *Orbitoides* (*mantelli?*)	5 feet
1,	Soft argillaceous white limestone	4 feet

Lithologically these strata resemble very closely those of the Claiborne Lisbon formation. A similar section on the Pea River has been described by Langdon,* of which he is doubtful as to the exact stratigraphic position, whether Jackson or Claiborne. Other exposures of probably Jackson age occur in Covington and Conecuh Counties and on west to the Mississippi line.

Smith† has described the following section showing 60 feet of Jackson on the Alabama River.

Strata exposed in continuous bluffs between Marshall's Landing and Rattlesnake Bluff, just below Claiborne, showing relative positions of the White Limestone and the Claiborne sands, Alabama River.

	Marianna Limestone:	
9.	Orbitoidal White Limestone of usual character	10 feet
	Jackson Formation:	
8.	White Limestone, containing great numbers of *Scutella lyelli* and other echinoderms	10 feet
7.	Calcareous clay in two beds of five feet each separated by three feet of soft, earthy White Limestone. Below this a ledge of hard limestone three feet and eight feet of blue clay with fucoids, becoming more calcareous below, in all	about 20 feet
6.	Ledge of hard, white limestone, followed by twenty feet or more of argillaceous, soft, white limestone at intervals. Resembles the rotten limestone of Cretaceous formation	About 25 feet
5.	Bed of *Scutella lyelli*, in three layers, the middle one ferruginous	3 feet
4.	Coarse ferruginous sand, calcareous below, hard ledge at bottom	6 feet
	Claiborne Group:	
3.	Claiborne ferruginous, fossiliferous sands, the counterpart of those at Claiborne Bluff	10-12 feet

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*Op. cit., page 381.

†Op. cit.

2. Calcareous, sandy clay, with hard ledge in middle 6 feet
1. Sandy, clay marl, with *Ostrea sellaeformis*, four or five hard ledges passing into greensand below 12 feet

Cooke* describes a Jackson and Claiborne section in Choctaw County as follows:

Section at Willow Branch, 4 miles from Silas, Alabama.

Post-Vicksburg:
13. Red sand to top of hill; about 50 feet

Jackson Formation:
12. Drab calcareous clay with white calcareous concretions 25 feet
11. Yellowish marl with *Pecten perplanus* and *Periarchus pileus-sinensis?* Indurated in lower portion 11 feet
10. Fine-grained yellow sand 21 feet
9. Argillaceous yellow sandy marl with shells; grades into the underlying bed 9 feet
8. Greenish-yellow clay with shells, forming a gentle slope, about 50 feet

Claiborne Group:
7. Hard gray indurated marl with small grains of glauconite and a few fragmentary shells 1½ feet
   Note—The measurements of the beds above No. 7 were made on the south side of the valley; of those below, on the north side.
6. Reddish-brown ferruginous glauconitic sand containing casts of mollusks, with a 1-foot shell bed at bottom 7 feet
5. Dark gray to black sandy clay with shells 3½ feet
4. Laminated gray sand and clay with *Oreodaphne inequilateralis and Mespiladaphne columbiana* 7 feet
3. Dark green to black glauconitic sand loaded with Claiborne shells 2 feet
2. Dark green to black, somewhat sandy clay. Weathers with fissile parting resembling "coal Blossom" 5 feet
1. Reddish-brown ferruginous sand to stream bed (1 to 2 feet concealed at bottom) 10 feet

This section shows 116 feet of Jackson.

The Jackson formation contains mostly limestone in Georgia and Florida, getting less calcareous to the west until in Alabama and Mississippi it is made up primarily of calcareous clays and limestone and glauconitic sands and clays. In Georgia the hard Jackson limestones cause a steeply rolling, rugged topography with cuestas having their steep slope on the north and the gentle slope to the south. In the Alabama, however, the soft nature of the beds give rise to a rather monotonous topography except where associated with the ridges and hills in the Claiborne belt and the hard beds of the Vicksburg. Characteristic fossils of the Jackson are *Periarchus pileus-sineuris*, *Orbitoides*,

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*Cooke, C. Wythe; op. cit.

Ostrea sellaeformis, Pecten perplanus (typical), etc., etc. *Zeuglodon centoides* bones are found in the Jackson in what is known as the "Zeuglodon bed."

OLIGOCENE.

The line of division between strata of Eocene and Oligocene age has been placed between the Jackson formation and Vicksburg Group. The latter lies conformably upon the former and from the very similar nature of the materials of the two series of beds it is quite evident that the conditions of sedimentation were entirely similar. In western Alabama clays and marls of the Red Bluff Clay member of the Vicksburg rest on clays and marls of the Jackson. Along the Alabama the two formations are composed primarily of more or less impure limestones which persist eastward into Georgia and Florida, but becoming more pure. The faunal life of the two seas was also quite similar but there were distinctive species in each, upon the basis of which the line of division was so placed.

The Oligocene in Alabama is composed of the following formations, in descending order:

Hattiesburg Clay (Grand Gulf).—Blue and gray clays and sands, of non-marine origin. Thickness near 300 feet.

Catahoula Sandstone (Grand Gulf).—Sandstones, sand and greenish clays of probable non-marine origin. Thickness near 200 feet.

Salt Mountain Limestone.—Hard massive limestone composed largely of coral, about 100 feet.

Vicksburg Group.—Including Marianna limestone and the Red Bluff Clay. Hard limestones, soft argillaceous limestones, marl and clay. Thickness 125 to 200 feet. Dr. Smith* formerly included the Catahoula sandstone and Hattiesburg clay together as the Grand Gulf Group, but later geologists and paleobotanists† have separated the group into the above named formations. In Alabama the Grand Gulf is very difficult of separation except upon minute paleontologic studies and therefore it seems that the term "Grand Gulf" of E. W. Hilgard is a fitting one to retain for less minute and detailed descriptions. Eastward into Florida and Georgia the Hattiesburg and Catahoula apparently merge into the Alum Bluff Clays and the Chattahoochee Limestone.

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*Op. cit., "Geology of the Coastal Plain of Alabama.

†Matson, C. M. and Berry, E. W. "The Catahoula Sandstone and Its Flora." U. S. G. S., Prof. Paper 98-M. 1916.

VICKSBURG GROUP.

The Vicksburg Group included by Smith in the "St. Stephens Limestone" has been separated into two parts, namely, the Marianna limestone at the top and the Red Bluff Clay of Hilgard at the base. In turn the Marianna limestone, named for the type locality at Marianna, Florida, has been subdivided in western Alabama into the Glendon limestone above and the Chimney Rock below by C. W. Cooke. E. A. Smith likewise recognized and described these distinctive beds but included them under his group name "St. Stephens Limestone."

The St. Stephens Group including the Jackson and Vicksburg forms the surface in a belt from ten to twenty-five miles wide extending from the Mississippi line in southwestern Choctaw County, where the belt is narrowest, to the southeastern corner of the State. The dip varies from probably twenty-five feet per mile in western Alabama to as little as ten feet per mile near the Chattahoochee River. Over this entire area the Vicksburg and Jackson terrane is covered with sands and clayey sands of later age which obliterate any characteristic soils which might have been derived from the calcareous beds. The only exposures, with a few exceptions west of Monroe County, are in the immediate stream banks and beds. The limestones give rise to a rugged topography in areas in western Alabama where the harder Glendon limestone is prominent while east of Monroe County the surface is generally lacking in distinctive features. The thickness of the Vicksburg varies from about 140 feet in West Alabama to possibly 175 feet or more in southeast Alabama and Florida.

RED BLUFF CLAY.

The lowest beds of the Vicksburg consisting of glauconitic marls at the base and clays with gypsum crystals and impure limestones above, have been called Red Bluff from its exposures along Chickasaway River in Mississippi.* At its type locality in Mississippi the Red Bluff attains a thickness of 60 feet while in western Alabama it has thinned to 30 or 40 feet and along the Alabama River to probably little more than 15 feet. In eastern Alabama no typical Red Bluff beds have been found.

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*Lowe, E. N. Mississippi: Its Geology, Geography, Soils and Mineral Resources. Miss. Geol. Survey, Bull. 12, 1919, pp. 89-90.

The fossils of the Red Bluff clay are those characteristic of the Vicksburg Group, e. g., *Pecten poulsoni* (typical), *Spondylus dumosus, Ostrea vicksburgensis*, etc., etc. Cooke† has described the following section, which shows the relation between the Red Bluff clay and the Jackson formation.

Section three and one-half miles southeast of Cullomburg, Alabama.

8. Concealed to top of hill; about .... 50 feet

Red Bluff clay member of Vicksburg limestone:

7. Very plastic gray clay with crystals of gypsum. Contains *Pleurotoma plutonica?, P. congesta, Busycon, spiniger, B. nodulatum, Phos macilentus, Ostrea vicksburgensis, Pecten aff. P. poulsoni, Spondylus dumosus, Corbula perdubia* .... 22 feet
6. Green-gray or buff glauconitic marl, consisting of grains of green glauconite the size of bird shot, in a white calcareous clay matrix. In the upper portion are several discontinuous ledges, and at the top is a more persistent ledge. Contains *Balanophyllia caulifera, Ostrea vicksburgensis, Pecten cocoanus. Pecten aff. P. poulsoni, Spondylus dumosus, Corbula sp.*, and *Astarte triangulata.* The *Ostrea* and *Spondylus* weather out of the lower 2 feet in great abundance but are difficult to see in the unweathered material .... 9 feet

Jackson Formation:

5. Stiff calcareous clay, yellow or buff on weathered surface, bluish green on damp fresh surface. Contains small irregular concretions. Merges into the overlying bed .... 8 feet
4. "Zeuglodon bed," buff argillaceous marl, merging into the overlying bed. Forms a gentle slope. Contains Flabellum, *Schizaster armiger, Ostrea falco, O. trigonalis.,* Gryphaeostrea, Pinna, *Modiolus cretaceus, Pecten perplanus, Terebratulina lachryma* .... 9 feet
3. Gray to yellow, very calcareous, argillaceous marl with some hard ledges. Forms steep slope. *Pecten perplanus, Ostrea trigonalis*, and Bryozoa abundant; other fossils represented by casts .... 6 feet
2. Yellow calcareous sand with poorly preserved shells and casts of Leda . Some calcareous concretions at base .... 18 feet
1. Steel-gray sandy calcareous clay; about .... 3 feet

MARIANNA LIMESTONE.

In western Alabama that portion of the St. Stephens which Smith called "Orbitoidal Limestone" and correlated with the Vicksburg of Mississippi has been identified as being equivalent to the Marianna of Florida by Cooke.‡ In the Tombigbee River section the upper 12 to 16 feet is a hard semi-crystalline, yellowish limestone which weathers into smooth, irregular rocks locally called "horsebone." This is the Glendon member of Cooke. Underlying this is the soft Orbitoidal limestone or "Chimney rock" which is from 90 to 110 feet thick in the Alabama and Tombigbee River section. Eastward into Florida and Georgia this bed holds its principal characteristics and reaches a thickness of possibly 175 feet in southeastern Alabama and Florida. The fossils present are those in the Red Bluff and abundant *Orbitoides mantelli.* Many other genera are liksewise present. It is well to note that the fossil *Venericardia planicosta* so very typical and abundant in the Wilcox and lower Claiborne formations is comparatively rare in and above the Lisbon formation though existing up into the Vicksburg.

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†Cooke, C. W. The Age of the Ocala Limestone. U. S. G. S., Prof. Paper 95-I, 1915, p. 116.

SALT MOUNTAIN LIMESTONE.

The Salt Mountain or Coral Limestone, named by Dr. E. A. Smith for the locality at which it is well exposed, Salt Mountain in Clarke County, consists of beds of hard and soft limestone with very abundant corals. This limestone has only been found in this immediate locality and thereafter seems to be of very local origin and will not enter into the vertical sections in Alabama except as a local unit. Dr. Smith estimated the thickness at 150 feet with which he probably included 15 feet of Vicksburg Glendon. Hopkins has later estimated the thickness to be 80 to 90 feet.

GRAND GULF GROUP.

CATAHOULA SANDSTONE.

The landward limit of the Grand Gulf formations, of which the Catahoula sandstone is the lower member, is a practically straight line extending northwestward from Florida to the northwest corner of Washington County. The Catahoula consists of sandstones, quartzite, sands and clays with the arenaceous sediments representing the much larger proportion of the entire thickness of 200 feet in Alabama as estimated by Matson.* The formation is largely covered by sands and sandy clays of more recent age so that exposures are rather rare and the formation does not extensively determine the character of the soils over the area in which it comes to the surface. Practically all the exposures are confined to the banks of streams. Outcrops are present near Healing Springs in Washington County and near Brewton in Escambia County. The dip of the Catahoula has not been definitely determined but it is probably near 20 feet per mile. The beds are of non-marine origin in western Alabama, becoming of marine origin to the eastward and probably merging in Florida into the Chattahoochee limestone.

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‡Op. cit.

HATTIESBURG CLAY.

The upper portion of the Grand Gulf, recognized as being equivalent to the Hattiesburg clay of Mississippi and so named in Alabama, consists of sands, clays, lignitiferous sands and clays and lignites. As is the case with the underlying Catahoula sandstone the surface terrane of the Hattiesburg clay is so covered with sands of the Lafayette and later formations that it has little or no effect on the soils of its area of outcrop. The exposures are very few and then only in the banks of streams crossing the formation. The best exposures to be seen in Alabama are in the vicinity of Roberts in Escambia County. In Western Alabama the formation is probably non-marine but near Roberts L. C. Johnson† found marine fossils. Eastward into Florida and Georgia the Hattiesburg merges into the Alum Bluff clays. Matson has estimated the maximum thickness of the formation in Alabama to be about 300 feet. The normal dip is near 20 feet per mile to the southward.

MIOCENE.

PASCAGOULA FORMATION.

From the nature of the materials along the contact of the Pascagoula and the Hattiesburg and the apparent varying thicknesses it is evident that an unconformity exists between the Oligocene below and the Miocene above. The

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*Op. cit.

†Op. cit. Geology of the Coastal Plain of Alabama.

extent of this unconformity has not been determined though it has been recognized by several geologists. The Pascagoula formation consists in the main of blue clays and sands containing fossils, primarily of microscopic size, which indicate a marine origin. The extent and thickness of the Pascagoula has not been definitely determined though Matson[*] has estimated a thickness of 250 feet and Dr. Smith[**] determined Miocene fossils at a depth of 735 feet in a well at Mobile, which would indicate a greater thickness. From the information gained by the plotting of well logs in the Mobile vicinity but without the advantage of microscopic examination of the cuttings, the Pascagoula appears to have a thickness of at least 400(?) feet with a dip seaward of upward of 20 feet per mile. As is the case with most of the formations which come to the surface in the southern part of the State, practically the entire formation is obliterated by sands and sandy clays of the Lafayette and later formations. L. C. Johnson[†] first described and named the Pascagoula formation in Mississippi in 1890. Few, if any, exposures in Alabama are definitely referable to the Pascagoula on the basis of their fossil content, though, from their geographic position, exposures along Chickasabogue and Cedar Creeks belong in this formation.

PLIOCENE-PLEISTOCENE.

LAFAYETTE FORMATION.

Along the Atlantic and Gulf Coastal Plain there is a system of sands, clays and gravels that were originally called "Orange Sand" by Safford, of the early Tennessee Geological Survey, and Hilgard, of Mississippi. They included in their "Orange Sand" sands and clays that ranged in age from probably pre-Pliocene to Pleistocene. Later McGee used the term "LaFayette Formation" to replace the earlier name and at the same time restricting it to apply to deposits of Pliocene and probably early Pleistocene age. Smith and Johnson have used the name in Alabama to apply to Pliocene and possibly early Pleistocene deposits. Matson and Berry‡ have made a later study in which they have further subdivided the Lafayette and abandoning that name for their new name, "Citronelle Formation." In this report the original name "Lafayette" is retained since the character and position of the deposits of Pliocene age and possibly early Pleistocene are of sufficient uniformity and similarity to warrant incorporation under one title.

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[*] Op. cit.

[**] Op. cit., p. 93.

[†] Op. cit.

Following the deposition of the Miocene strata the sea receded to possibly near its present margin during which time the most of the present land area was above water and being subjected to a more or less rapid denudation . The sea then transgressed landward for probably seventy-five to one hundred miles north of the present shore line, during which short time the sands and clays of the near shore Lafayette were deposited (the Citronelle of Matson and Berry). Near the close of the Pliocene, which was very short as far as the present surface formations indicate there must have been a very rapid transgression of the sea to a line probably 200 to 250 miles north of the present shore line, covering a topography very similar to the present but with less marked relief. When the sea had transgressed to its landward limit it was caused to regress rapidly by the elevation of the land area of northern Alabama. This land elevation resulted in swift streams bringing down abundant heavy sediments of sand and gravel depositing them as terraces and deltas and in some cases probably great alluvial fans. At the end of this rapid regression the shore line probably reached its present position. Throughout the Coastal Plain the landward Lafayette covers indiscriminately all of the Cretaceous and later deposits and even overlapping onto the Paleozoics and Crystalline rocks. The appearance is that the upstate Lafayette occupies a fourth and highest terrace. The sands, sandy clays and gravels of the inland portion reach a thickness of 25 to 30 feet and is the common gravel bed material of middle Alabama. Further southward the sheet deposit of Lafayette probably attains a thickness of 200 feet being the high terrace materials along the coast. (The above expressed theory of the origin of the Lafayette does not coincide with the views of Dr. Smith, nor is the writer entirely satisfied with the explanation.)

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‡Matson, G. C. and Berry, E. W. "The Pliocene Citronelle Formation." U. S. G. S. Prof. Paper 98-L.

PLEISTOCENE.

UNIVERSITY TERRACE.

After the Lafayette was deposited and the shore line had been disturbed by comparatively slight oscillations, the inland streams had been widening their valleys and forming more or less extensive flood plains. Upon elevation of the land area the streams began to rapidly deepen their channels, leaving the former flood plain as the present University terrace, so named in this report, after a conference with Dr. E. A. Smith, for the typical broad terrace upon which the University of Alabama is located. Montgomery, Selma, Eufaula and Claiborne are likewise on the University or third terrace while it is well defined along the Gulf through middle Mobile and Baldwin Counties.

NORTHPORT TERRACE.

After the streams had cut down for probably 80 to 100 feet they again began to widen rather than to deepen their valleys, forming wide flood plains. Another elevation of the land caused the streams to further deepen their channels leaving the flood plain as the second or Northport terrace, named in this report for the typical terrace on which Northport, Tuscaloosa County, is located. The terrace is further defined as being between the University Terrace and the present flood plains. The University Terrace is from 100 to 160 feet above the present drainage levels while the Northport is about 50 to 75 feet above. The University Terrace is made up of sands and silts with considerable gravel near the crystalline and Paleozoic areas. The red gravels are easily mistaken for Lafayette and in fact are probably in many deposits reworked Lafayette gravel. The Northport Terrace is composed largely of yellowish silts and clays with more or less sand in places.

RECENT.

The First Bottom or present river flood plain deposits consist of silts, sands and gravel dependent in variety primarily upon the nature of the formation composing the drainage areas of the individual streams. The Chattahoochee River above Columbus, Georgia, runs entirely through the Piedmont area of old crystalline and later igneous rocks and in consequence transports sands and pebbles of various varieties and silts and clays that are principally derivative of decomposed feldspars and other igneous minerals together with clays from the rather complex schists and other metmorphosed sediments of the Piedmont or crystalline area. The sands and pebbles are less worn and rounded than those of streams draining areas of sedimentary rocks because of the shorter distance of transportation.

These materials occur in the flood plain to thicknesses of as much as fifty feet in some instances with the sands and gravels predominating in the lower portion and the clays in the upper part. The clays are normally of a reddish color because of the rather high iron content and the small amount of humus transported with the clay.

The Alabama River drains a considerable area of Paleozoic formations in northwest Georgia and northeast Alabama and a lesser territory in the Piedmont section. Paleozoic beds are mostly limestone and shales with some sandstones while the crystalline rocks are granites, quartzites, schists, and so on. The Paleozoics furnish a relatively finer and more plastic clay with a lower iron content and a more rounded sand and pebble because of the greater distance of transportation, it having been deposited in the old Paleozoic seas and now undergoing further transportation. These materials when redeposited along the stream flood plain and along and in the Gulf of Mexico form beds of rather plastic clays and rounded sands with an admixture of the less plastic red clays and sharper sands from the Piedmont.

The Warrior and Tombigbee Rivers drain areas of the Paleozoic rocks as well as Cretaceous and later formations and carry a burden of less clay in proportion to the sand.

All of these streams drain large areas in the Coastal Plain and are again moving materials that were derived from the areas of the present upper reaches of the drainage channels and deposited under conditions somewhat analogous to the present.

Along the Coastal strip the materials being deposited are sands obtained from the mouths of the various streams entering the Gulf and moved and redeposited by the action of the waves. The silts are being deposited along the Coastal strip beyond the limit of the stream currents.

These first bottom deposits occupy comparatively narrow strips along the rivers and the Gulf Coast and probably attain a thickness in places of fifty or sixty feet. They are readily distinguished by their position along both the rivers and the coast.

STRUCTURE.

The Coastal Plain area of Alabama is in general aspect a monocline, being a comparatively small segment of that great monoclinal nose which is described about the southwestern extension of the Cumberland Paleozoics, the Appalachian Mountains and the Piedmont area, which we will call the Appalachian Peninsula. The normal direction of the dip about the nose is from southeast on the Atlantic seaboard to northwest in Tennessee and Kentucky or at the normal direction to the short line about the peninsula. The degree of inclination of the old Cretaceous sea floors of Pre-Cambrian and Paleozoic rocks can be determined only where wells, which are few in number, have been drilled through the mantle of Coastal Plain materials and into the basement rocks below. In Alabama the Cretaceous sea floor of Pennsylvanian rocks probably had an inclination of slightly more than 30 feet per mile to the southwest while the metamorphosed rocks under the Cretaceous sea had a southerly inclination of upward of 40 feet per mile. From Louisville, Georgia, north to the Fall Line the basement rock surface dips from 50 to 60 feet per mile, S. 70° E.

The dip of the Cretaceous strata varies from 35 to 40 feet per mile in the lower part of the series to 30 feet per mile in the upper portion. On the eastern side of the State the direction of dip is south while in western Alabama and eastern Mississippi the direction is southwest. Southward toward the Gulf from the formations of Cretaceous age the dip of the strata decreases to a probable minimum rate of nearly 20 feet per mile along the coast. Based on the data secured from the logs of numerous wells drilled in the area south of the outcrop of the Selma Chalk the dip of the base of this formation is thirty-five feet per mile while measured dips in the Eocene show that the formation have an inclination approximating 30 feet per mile. Along the coast the dips cannot be definitely determined.

There is present in the southern portion of Alabama a system of folds and faults having an axial trend of about thirty degrees north of west. This trend can be traced southeastward almost across the State of Florida and westward into Mississippi, and is parallel to the axes of certain mountain and fault systems of the southwest which is suggestive of a contemporaneous origin from the same tectonic forces. This is also the approximate direction of the axes of the Red River folds of Northern Texas. A second system of folding in southern Alabama, while not as yet definitely determined, seems to have an axial direction only slightly west of north. It is possible that this system is more closely related to the major series of folds than the apparent trend would indicate. All of these movements are post-Eocene and probably comparatively recent. A very recent movement has caused the drowning of the mouth of the Mobile River and the consequent result of a rather shallow syncline. The several known folds of southern Alabama will be described very briefly on the next succeeding pages.

Geneva Structure.—The normal surface terrane of the Claiborne formation in southeast Alabama crosses the southern portion of Coffee County where it dips to the southward below the surface at the rate of about 25 feet per mile, being covered along the southern border of the county by the Jackson and Vicksburg formations. The Claiborne is again exposed in the creeks and rivers in the immediate vicinity of the town of Geneva. The Claiborne passes below the surface in Coffee County on Choctawhatchee River. With the usual rate of dip of 25 feet per mile the normal position of the Claiborne would be 250 feet below the surface at this latter point which is indicative of a fold or uplift of the strata. No contact of different beds or bedding planes can be observed along the streams where the Claiborne is exposed from which dips can be read to delineate the structures. Also there is no bed in the Claiborne on this uplift that can be safely used as a key horizon and traced throughout the various exposures. Outcrops of beds referable to the Claiborne occur in all of the streams close to Geneva and though their exact horizon in the Claiborne cannot be determined they are evidently of the upper portion since the overlying Jackson and Vicksburg formations closely encircle the area in which the Claiborne is exposed.

In the banks of Double Bridges Creek one mile north of Geneva, where the Bellwood road crosses, there are good exposures of calcareous sands containing large silicified shells of *Ostrea sellaeformis.* Overlying this is white sand of terrace origin. On the Dothan road where it crosses Choctawhatchee River the same beds are exposed. In the road cut a short distance northeast of the river and 50 feet above there are large boulders of silicified limestone containing *Orbitoides, Pecten,* etc., that is probably referable to the Vicksburg though occupying the stratigraphic position of the Jackson. This position of the boulders may have resulted from the softer Jackson having been eroded away, letting the boulders of more resistant flint rock work down into its horizon. On the road to the east of and parallel to Choctawhatchee River, six to ten miles southeast of Geneva, there are exposures of blue argillaceous sands underlain by fossiliferous calcareous sands and argillaceous limestones that are referable to the Jackson. In the country east of this road are frequent large boulders of fossiliferous silicified Vicksburg limestone. At Hall's Mill on Beaver Dam Creek, some four or five miles northwest of Geneva, there is an exposure of fossiliferous sandy limestone that is apparently about [illegible] of the Claiborne or the base of the Jackson. [illegible]anks of the Pea River near its confluence with the Choctawhatchee expose some ten feet of sandy limestone devoid of fossils which from its stratigraphic position and lithologic character is referable to the Claiborne.

The area around Geneva in which the Claiborne comes to the surface, is some six miles in length north and south and slightly less east and west. The elevation of the top of the Claiborne above its normal position is somewhat more than 250 feet.

Lower Peachtree Anticline, Figures 25 and 26, so named by Smith from the village of Lower Peachtree on the Alabama River in southwestern Wilcox County, which is situated approximately on the crest of the fold, may be best determined in cross-section along the Alabama River from Yellow Bluff to a point one mile below Bell's Landing. At the edge of the water at Yellow Bluff during low water stages of the Alabama River, there is exposed a marl bed of the upper portion of the Tuscahoma formation that is characterized by very large *Voluta newcombiana* and *Venericar-*

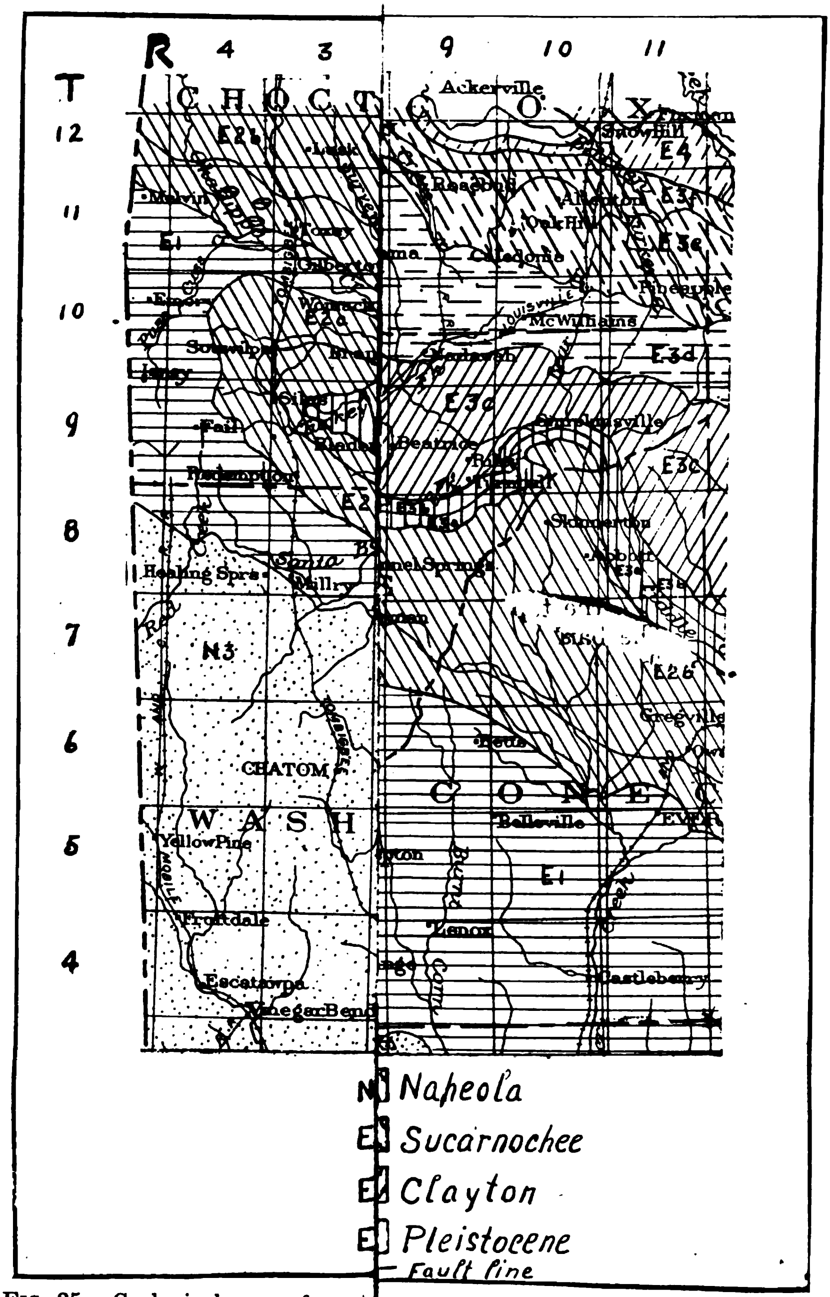
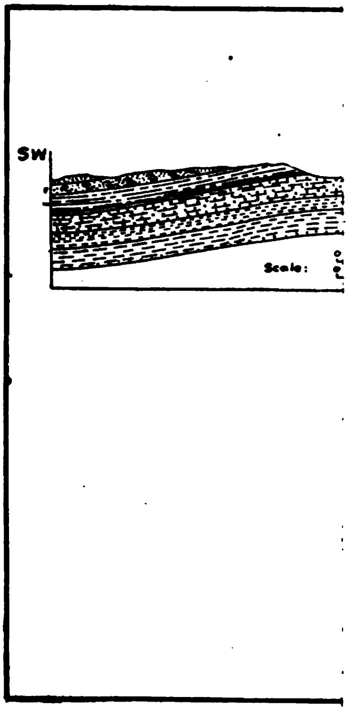


FIG. 25.—Geological map of part e Bethel faults and the outline of the Beatrice fold. Cop n anticlinal made in 1905.



the width of the outcrop of the Tuscahoma formation in northern Clarke and southern Marengo Counties considered along with the thickness of the formation and the normal dip, the possibility of the structure extending for some distance northwestward presents itself. The width of the outcrop in this area is about fifteen miles, while the normal dip is not less than 30 feet per mile and the thickness of the formation probably little over 200 feet. Therefore, it seems

dia planicosta. This same bed is exposed at Lower Peachtree Bluff four miles south of Yellow Bluff at an elevation of about 1C0 feet above the river level. Continuing downstream in a southeasterly direction the same fossil horizon is again seen at Bell's Landing, eight miles below Lower Peachtree, at an elevation of forty feet above the water. At this point the river bends to the southwest, crossing the west side of the anticline. About a mile further downstream to the southwest the marl bed passes below the surface of the water. From Lower Peachtree upstream to Yellow Bluff there are practically continuous exposures that allow the reading of dips which average between thirty and forty feet per mile. At Yellow Bluff the marl beds at a rate of fifty feet per mile from the lower to the upper end of the bluff. One mile upstream, east, a low bluff exposes the lower beds of the Bashi formation which are 70 feet above the Lower Peachtree marl bed of the Tuscahoma. This exposure is against the fault plane of the Bethel fault which will be mentioned later. Thus the position of the marl bed in Lower Peachtree Bluff is 170 feet higher than the same marl bed on the south side of the Bethel Fault, four and one-half miles northeast. Overlying the Tuscahoma formation at Yellow Bluff the Bashi formation is exposed in complete section, above which the lower 100 feet of the Hatchetigbee beds may be seen. See description of the Yellow Bluff section. The next exposures of Bashi and Hatchetigbee strata are at Davis' Ferry, six miles downstream from Bell's Landing.

No attempt has been made to trace the Lower Peachtree Anticline east of the Alabama River but it probably does not extend further than the middle of Range 7 west, where a slight syncline is present, apparently lying between the above anticline and the Beatrice fold. Westward of the Alabama River no definite evidence of the continuation of the Lower Peachtree Anticline has been recorded, but from the width of the outcrop of the Tuscahoma formation in northern Clarke and southern Marengo Counties considered along with the thickness of the formation and the normal dip, the possibility of the structure extending for some distance northwestward presents itself. The width of the outcrop in this area is about fifteen miles, while the normal dip is not less than 30 feet per mile and the thickness of the formation probably little over 200 feet. Therefore, it seems that there has been at least a flattening if not an actual folding of the strata. There is also the possibility of a structural terrace or fold not connected with the Lower Peachtree Anticline.

The Bethel Fault (see Figures 25 and 26), so named by Smith from its occurrence near Bethel, in western Wilcox County, has a direction parallel to the axis of the Lower Peachtree Anticline, about N. 30° W., and limits the structure on the northeast side. There seems to be a very close relationship between the formation of the two structural features, they probably having been formed contemporaneously by the same tectonic force which acted in a direction normal to their axes. The fault plane is exposed in a low bluff on the Alabama River, one mile upstream and east of the upper end of Yellow Bluff, where it is seen to dip at an angle of near fifty-five degrees to the northeast. An unusual feature of the fault is that on the upthrow side, northeast, the strata dip away from the fault plane while on the downthrow side, southwest, the beds dip toward the fault. This is just the opposite to the structure of the normal fault, while it is difficult to conceive of a reverse fault movement in strata of this character with no more deformation of the beds in immediate contact with the fault plane than is shown in the exposure. The actual plane of the fault is clean and smooth while the strata in contact with it dip to the northeast at the rate of eight percent on the downthrow side and six percent on the upthrow side. This rather steep dip obtains for only a short distance on either side where it merges into the regular reverse dip of the Lower Peachtree Anticline. Northeast of the Bethel Fault the northeast dip continues for three-fourths of a mile making a reversal of seventy feet, which, added to that of the anticline, makes a total reversal of 240 feet.

On the northeast side of the fault the *Gryphaea thirsae* marl of the Nanafalia formation is exposed for six feet above the water, being overlain by the kaolin-like clay of the upper half of the Gullette Bluff beds. On the southwest or downthrow side beds twenty feet above the base of the Bashi formation are in immediate contact with the marl. Below this bed of the Bashi there are twenty feet of this formation, 150 to 160 feet of Tuscahoma strata and about 10) feet of Gullette Bluff beds above the marl. Therefore, the bed in contact with the Gryphaea marl on the opposite side of the fault plane is about 270 feet stratigraphically above the marl, which shows a vertical displacement of that distance. Dr. Smith traced the fault from west of Bethel, where he found the displacement to be about 150 feet, to Section 24, Township 11 N., Range 6 E., east of the river, where he determined the throw to be near 300 feet. East of this locality the fault lessens rapidly in intensity and apparently ceases near Nellie. This eastern limit of the fault seems to conform with the eastern limit of the anticline, and it is probable that the fault extends as far to the westward as the fold.

The Lower Peachtree Anticline, as known at the present time has an axial direction of N. 30° E., extending from near Tinela, Monroe County, through the village of Lower Peachtree and on northwestward for at least ten miles. The width of the fold is nearly 8 miles while the maximum reversal is between 170 and 200 feet without considering the northeast dip on the upthrow side of the fault which adds 70 feet in a distance of less than one mile. The length of the Bethel Fault is probably the same as that of the fold, about fifteen miles, with a maximum throw of probably as much as 300 feet. There are dips on either side of the fault which are the reverse of the normal dip of the Alabama Coastal Plain. If the folding movement conforms to the fault displacement the highest point of the anticline is probably two or three miles southeast from Lower Peachtree, along the axis of the structure. However, in order to closely determine the area of the structure having the best possibility of yielding petroleum, a much closer study is necessary than those from which the writer has data. Another area worthy of very close study and consideration is the reverse dip on the northeast side of the fault. This fault plane at depth possibly offers a good channel for migration of petroleum from the deeper beds while it should be prevented from moving further upward than the base of the Selma Chalk, which, because of the nature of the material, should act as a sealing medium throughout its 1,000 feet thickness along the fault plane.

The Beaver Creek Anticline named for the creek of that name, which is just north of the fold, was observed at two points in the central part of Marengo County. At Nolan's Store in Section 23, Township 14 N., Range 1 E., beds of the Coal Bluff phase of the Nanafalia formation are exposed in the road cuts for a distance of somewhat more than one-fourth mile. Northward from this belt of Coal Bluff beds the Gullette Bluff strata compose the surface over a strip of country about two miles wide. In the south scarp of the branch below Nolan's Store Gullette Bluff beds are again exposed. Thus we find a narrow strip of Coal Bluff beds as an inlier in the higher strata of the Nanafalia formation. This is not entirely due to the presence of a fold for the stream mentioned above has cut through the upper beds and into the lower but this does not entirely account for the occurrence. Where the contact of the Coal Bluff and the Gullette Bluff beds was seen in the road northeast of the store, the bedding planes have a dip of two to three percent to the northeast and north of this the hard ledges of the upper part of the Nanafalia beds seem to be near horizontal for a distance of a half mile. In the road cut in front of Nolan's Store the Coal Bluff beds dip at the rate of five percent to the northeast. Across the creek to the south the strata have resumed their normal direction of dip but at a rate considerably greater than normal.

In Section 36, Township 14 N., Range 1 E., on the Linden-Sweetwater road, the contact of the Coal Bluff and Gullette Bluff beds has a northeast dip of three percent while one-fourth mile northeast of this point the lignite bed near the base of the Coal Bluff dips four feet in five hundred in the same direction. One-half mile north of this point the normal southwest dip was observed in the same lignite bed. On a steep hill on the road in the south part of the section the upper beds of the Nanafalia have a dip of probably two percent to the northeast. Immediately south of this point no exposures were seen but it is assumed from the outcrops further southward that the normal dip obtains. No other investigations were undertaken in this area so it is impossible at this time to do more than mention the two points at which cross-sections of an anticline were made and the possible connection between the two. The cross-section made at Nolan's Store is about twenty degree north of west from the section northeast of Sweetwater, which, though not the usual direction of the axes of the structures of southern Alabama it is sufficiently near to assume that the two cross-sections are on the same fold. The northwestern end is hardly as much as a mile wide while the reverse dip where seen northeast of Sweetwater is at least a mile in length.

We assume then that there is in that portion of Marengo County immediately south of Beaver Creek a small anticline having an axis trending N. 70° W. To the southeast from Nolan's Store the fold increases in size at least to the Linden-Sweetwater road, two to three miles north of Sweetwater. There remains the possibility that southeast of this last mentioned locality the structure becomes more extensive than yet seen.

Hatchetigbee Anticline (Figures 25 and 26).—The great fold in the Tertiary strata in southwestern Alabama was first studied and mapped by Smith and Langdon* and named "Hatchetigbee Anticline" for the formation of that name that has been exposed along the axis of the structure by the erosion of the younger formations which overly the Hatchetigbee formation. Later Hopkins† described and mapped the area of the structure and discussed the possibility of the occurrence of petroleum. In this report the description is largely a summary of the work of Smith and Langdon.

The Hatchetigbee Anticline extends from near the central part of Clarke County through the northern part of Washington and into Choctaw County to near the Mississippi line, having an axial direction of N. 55° to 60° W. The length of the structure as marked by the exposure by erosion of older formations than those that would normally cover the area is about 35 miles, while the maximum extent of the area affected is considerably more, probably 50 to 60 miles. The width of the fold from the trough of the syncline on the northeast to the point of equal stratigraphic elevation to the southwest is from 15 to 18 miles.

As mentioned above, the Hatchetigbee formation is exposed along the crest of the fold as an inlier for a distance of 20 miles while other formations lying stratigraphically above the Hatchetigbee likewise outcrop as inliers and encircle the highest part of the fold in the following order: Tallahatta, Lisbon, Gosport and Jackson formations. The Vicksburg is the normal formation of the area and it is within that terrane that the structure was formed. About fifteen miles northeast of the Hatchetigbee inlier that formations reaches the surface in its proper position as a member of the series of formations which compose the Coastal Plain monocline. Considering a dip of thirty feet per mile to the southwest as normal for this part of the monocline the Hatchetigbee beds exposed along the axis of the fold are at least 450 feet above the monoclinal position. According to Hopkins the axis of the structure is higher near Salitpa and Bladon Springs than the general level, while there is a saddle from Section 22 to Section 8, Township 8 N., Range 1 W. The southeastern end of the structure ends suddenly against the Jackson fault while the folding was probably effective northwestward into Mississippi. If the thickness of the formations below the surface of the folded area was the same as along their outcrops to the north, the top of the Selma Chalk would be encountered at from 1,200 to 1,250 feet below the surface, but from the log of the Mitchell No. 1, drilled in Section 26, Township 8 N., Range 1 W., the chalk was found at 1,700 feet below the surface. This shows a greater thickness by 400 feet than the sum of the thicknesses of the formation penetrated along their outcrops, The Selma Chalk shows a thickness of 950 feet, which is about the same as the thickness given by well logs and the surface outcrop up the dip from the well. In the Bollinger No. 1, Section 13, Township 9 N., Range 3 W., the chalk was entered at 1,980 feet. In the Cullom Springs well near Bladon Springs the Selma was encountered at 1,220 feet, according to Langdon,* who was on the ground at that time. This is about the calculated depth for the chalk. If the logs are correct the Cullom Springs well is on the calculated structural high while the other two wells cited are on low parts of the folds that, according to the surface data, should be as high as at Bladon Springs.

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*Smith, Eugene A., and Langdon, D. W. Geology of the Coastal Plain of Alabama, Alabama Geological Survey, 1894.

†Hopkins, Oliver B. Oil and Gas Possibilities of the Hatchetigbee Anticline Alabama, U. S. G. S., Bull. 661-H, 1917.

The area of the *Jackson Fault* was first worked over by Smith, who explained the abnormal position of the formations exposed due to a north and south fault or a steeply folded anticline. Later Hobson studied the area for the State Survey and considered that an anticline with a north and south axis was present. Hopkins‡ has made a more recent investigation and is of the opinion that a fault having a throw of 300 feet near its northern and at least 450 feet near its southern extremity extends from Section 12, Township 7 N., Range 1 E., southeast to a point two miles east of Jackson Station, where it bends southward to the Central Salt Works and thence southwest to and possibly across the Tombigbee River at the Lower Salt Works. No actual fault plane has been seen by any of the investigators but the relative positions of the several formations concerned in the surface of the area seem to preclude the possibility of accounting for the abnormalities by other than faulting. Both Smith and Hopkins found north of Jackson, Vicksburg or Orbitoidal White Limestone on the southwest side of a northwest-southeast line and Jackson limestone and Claiborne strata at about the same elevation on the northeast side of the line. South of Jackson, beds of Hatchetigbee age are exposed to the eastward in almost direct contact with Vicksburg limestone to the west. Hence the down throw side seems to be to the west and southwest of the fault zone. The strata on the west or down throw side of the fault dip toward the plane of displacement, according to Hopkins, while those on the east or upthrow side dip at the rate of two percent to four per cent away from the fault or to the east and northeast. It is a notable fact that the dip of the strata concerned in the Jackson fault bear the same relation to the fault plane as do the beds on either side of the Bethel Fault in Wilcox County.

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*Op. cit.

‡Op. cit.

The strata dipping northeast along the upper limb of the fault north of Jackson are in almost the reverse position to the normal direction of dip in this area of the Coastal Plain and therefore should act as a trap for the retention of any petroleum which might have migrated along the fault plane, provided it did not escape to the surface, and also that which might have migrated normally up the dip of the strata. This is an area that is suggestive of the possibility of the presence of petroleum in commercial quantities, other conditions being favorable. The area as mapped by Hobson is shown on the geological map of the Hatchetigbee Anticline accompanying this report, on which the probable fault is shown as an anticline.

The Beatrice Anticline (Fig. 25).—A deformation of the Coastal Plain strata from their normal position in northern Monroe County, Ranges 7 and 9 East, Townships 8, 9 and 10 North, is tentatively designated as the Beatrice Anticline. From a glance at the geological map of the area it is readily seen that the unusual trend of the several formations concerned suggests the possibility of some structural movement having caused the wide deviation from the normal position and direction of the outcrop of the beds. In attempting to check this apparent condition the writer used the base of the Tallahatta Buhrstone as the key horizon. Beginning on the Alabama River west of Franklin a ridge of Tallahatta Buhrstone with Hatchetigbee beds along the base extends northeast to near the Wilcox County line, a distance of ten miles, where it bends sharply to the south, continuing for eight miles to the southwest corner of Township 9 N., Range 8 E. From this point the ridge trends slightly south of east for eight miles, where it bends northeast to the north central part of Township 9 N., Range 10 E. Here the scarp turns southeast to Sepulga, Conecuh County. An excellent exposure of the contact of the Tallahatta and Hatchetigbee formations may be seen in the cut at the north mouth of the Louisville and Nashville Railroad tunnel in the northwest corner of Section 13, Township 8 N., Range 8 E., while the approximate and actual contact of the two formations can be traced along the scarp outlined above. By running aneroid barometer levels the key horizon was found to be about 100 feet lower on Flat Creek, eight miles slightly north of west of the tunnel, than at the latter point. Ten miles northeast of the tunnel the contact has an elevation of 40 feet lower than at the key locality. In the railroad cut north of the tunnel the beds show a dip of two per cent, S. 45° W. Considering the axis of an anticline or nose to lie a short distance west of the tunnel we find that the strata dip west and southwest and east and southeast from it. From the position of the Tallahatta at Tunnel Springs, three miles south, a sharp south dip obtains south from the tunnel. No data further than give above were secured in this area or northward in Wilcox County, except in the Grampian Hills immediately south of Camden. Here the Nanafalia beds were found to be flat with a possible very slight northward dip for a distance of a mile or more along the Camden-Fatama Road, some two to four miles southeast of Camden. At Vredenburg the base of the Nanafalia was found in a well at a depth of 200 feet. This should be in the trough to the west of the supposed structure and between it and the Lower Peachtree Anticline. The sharp northwest bend in the Alabama River at Bridgeport suggests the possibility of structural influence while the Ripley marls outcropping along this northwest reach of the river show some northwest dips which seem to be local but may have some connection with a more considerable movement to the southeast. Granting the presence of an anticline or monoclinal nose in Wilcox and Monroe Counties, the axis of the fold is most likely about N. 15° to 20° W. This area was very hurriedly covered and the study was only sufficient to indicate the advisability of a more thorough investigation of its possible relation to the accumulation of petroleum.

Other Areas of Possible Folding in Southern Alabama.—geological map of southern Alabama shows an area in which the trend of outcrop of the formations makes a wide swing to the southward in southern Butler and eastern Monroe Counties, similar in map appearance to the position of outcrop around the Beatrice Anticline to the west. The area which seems to be worth investigation lies between Commerce, Garland, Shell and Butler Springs on the west, south, east and north, respectively. A swing to the south of the formations between Red Level and Evergreen, together with the unusual width of the terrane of the Buhrstone outcrop suggests the possibility of folding or structural terraces possibly connected with the area to the northwest mentioned above. This southward swing may have been occasioned by the erosion effected by streams which flow southward through the areas but considering the comparatively slight relief and the very considerable southward displacement of the formation outcrop it does not seem likely that erosion alone accounts for the variation from the normal.

In Monroe and Conecuh Counties, south of Monroeville, the considerable width of the outcrop of the St. Stephens Group limestones suggests the possibility of small folds in the strata or the presence of structural terraces. There are likewise other localities in the Coastal where the possibility of folds or flattenings in the strata is suggested by the width and position of outccrops. In fact the monoclinal dip of the Coastal Plain formations is so comparatively slight that small folds or terraces might have been developed in almost any area without its being evident except through rather close and detailed study. A slight northeast or reverse dip shows in the Southern Railroad but a few miles north of Livingston, Sumter County, but it is not considered that the subsurface conditions in this area are particularly encouraging.

SALT DOMES.

West of the Mississippi River there are two groups of Salt domes, one of which occurs in the near coast strip where the surface formations are post-Miocene and the other group further inland, generally known as the "interior salt domes," where the surface formations are of Eocene age. In Texas and Louisiana the post-Miocene strata consist of some 4,000 feet of strata, while in Alabama beds of this age are only a few hundred feet in thickness. Hence we have in the latter state no conditions which are identical with those of the coastal salt dome area of Texas and Louisiana. Eocene and Upper Cretaceous formations of the interior salt dome region of Texas and Louisiana are practically identical with the same group in Alabama from which we might consider that in Alabama we have, above the base of the Upper Cretaceous, conditions similar to those in Texas, except that East Texas is synclinal while southern Alabama is monoclinal. The following article on salt domes has been kindly prepared by Mr. Robert T. Hill for use in this report:

SALT DOMES.

"In Texas and Louisiana there are peculiar geologic features with which oil is sometimes associated, known as salt domes. It is not always easy to determine the presence of these domes. They may occur as slight domical topographic elevations above the adjacent physiography, or as depression below the general surface. The area occupied by them and the disturbed strata surrounding them is small, seldom exceeding a mile or more in diameter.

Knowledge of the salt domes is comparatively new to science and they were practically undiscovered until the persistent explorations and operations of Captain A. F. Lucas in the salt and oil fields in central Louisiana and Texas in 1900-1902, made them known to the world. Although Lucas' discoveries and ideas were not at that time formulated in words, he first discovered the domical nature of the domes and demonstrated a deep salt core, the arching of the strata around them and the association of oil with them. The writer, in 1902, published an account of Captain Lucas' operations and results with his approval.*

These domes and their surroundings occur as vertical salt columns, sub-cylindrical in cross-section, which penetrate the Cretaceous, Tertiary and Quaternary strata from below. The upper end seldom appears at the immediate surface, sometimes having been dissolved away and covered with debris, and at other overlapped by the later strata which they have partially penetrated. The surrounding strata are flexed upward, around and over the upper end of the column of rock salt and correspondingly dip sharply away from them in every direction. The downward extent of the salt column in unknown. In Louisiana, as at Belle Isle, they were drilled into to a depth of 3,000 feet by Captain A. F. Lucas.

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*"The Beaumont Oil Field with Notes on Other Oil Fields in the Texas Region." Journal of the Franklin Institute, Philadelphia, an institute of Mining Engineers. New York, 1902.

The domes may be classified by location into two categories, as follows: (1) The salt domes of the Coastal belt, in which area the surface formations consist of nearly 4,000 feet of post-Miocene strata; and (2) salt domes of the interior, in which the surface formations are mostly Eocene, from Wilcox to Jackson, inclusive. The age of the Coast Domes is placed by both Wm. Kennedy§ and E. T. Dumble* as late Tertiary.

Dumble more definitely states it as "post-Lafayette-pre-Port Hudson," which is practically the late Pliocene or early Pleistocene.

According to Powers and others, the interior domes and the Coastal domes are of different ages.** Hopkins*** concluded that the East Texas domes were probably uplifted before the deposition of the Midway. Powers¶ fixes the uplift of the Butler dome as toward the close of the Midway.

ORIGIN OF THE DOMES.

Several theories have been advanced as to the origin of the domes which may be termed the hydrostatic, the tectonic, the "diapir" and the volcanic. The latter, which infers that the domes are indefinitely connected with sites of former volcanic activity and associated in origin with them, is too hypothetical for consideration and as the alleged data upon which this hypothesis is usually founded are fallacious, we do not think the theory worthy of consideration.

The hydrostatic theory originally advanced by the author in 1902, attributed the origin of the salt columns to the ascension and subsequent condensation of the salt in solution along lines of fissures. He gave no satisfactory explanation of the doming of the strata, nor did he realize then how extensively they were arched.

The tectonic theory holds primarily that the salt of older formations has been brought nearer the surface along the axis of anticlinal folds.†

The "diapir" theory propounded by Mrazec‡ is the tectonic theory plus one which holds that the salt has been bodily pushed up into and through the folds of strata in a semi-plastic condition. There are several supporting factors to the tectonic theory, the chief of which is the existence of structural conditions confirmatory of such a theory supported by the probable fact that rock salt may occur in the underlying rocks.

Inasmuch as the Mississippi embayment and Gulf of Mexico compose a deep synclinorium eastward of a former central Texas highland, the algebraic sum of the movement producing this condition has been subsidence in the embayment, accompanied by parallel step fault zones and folds of the Balcones and Mexico type.

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§Bull. Southwestern Association of Petroleum Geologists. Vol. 1, p. 51, 1917.

*Origin of the Texas Domes, Amer. Inst. Min. Engrs. Bull. 143, p. 1635, 1918.

**American Journal of Science, Feb., 1920, pp. 149-150.

***U. S. Geol. Survey. Bulletin 661, p. 263.

¶Op. cit., p. 139.

†See Origin of the Texas Domes, by E. T. Dumble, Amer. Inst. Min. Engrs. Bull. 143, 1918.

‡Les plis a noyaux de percement, Bulletin Scientific Society of Bucarest, 1906.

SOURCE OF THE SALT.

There is much speculation as to the origin of the salt in these domes. The occurrence of this salt, before its columnar nature was known, was theoretically considered by G. D. Harris as land locked lagoonal deposits, evaporated from the margins of the Cretaceous seas. Later the writer* assumed that these salt occurrences were not native to the strata in which they were found but were ascensional as hot saline solutions from still lower strata, and therefore of secondary origin. Waters now arise from fissures of this type known as the Balcones fault zone, and there is no reason why waters should not have arisen in the past through similar and parallel fissures to the east. Saline waters with increasing temperature with depths, also arise from deep wells at Marlin and elsewhere. The writer also held the salt and oil were contemporary in origin, but this hypothesis is no longer tenable for the salt column is now often known to penetrate beds in which the oil occurs.

Dumble** has recently expressed the opinion that "the salt of the Cretaceous (inland) domes probably has its origin in the evaporation of sea water in shallow basins during the period of Comanchean sedimentation or Mid-Cretaceous interval."

While it is true that gypsum, an accessory mineral to the salt, is found in basement littoral of the Comanche Cretaceous in Southern Arkansas, and which are of semi-continental nature and possibly the top of a series of lower "Red Beds," the writer is inclined, for reasons which will be presently be set forth, to consider that the original or mother source of the salt in the columns of the domes may have been in still lower strata.

Our reasons for this hypothesis are as follows: The Comanchean Cretaceous, which has been drilled into around these domes in several places in East Texas and Louisiana, so far as known, has the same deformation as that of the overlying strata and were therefore similarly penetrated by the salt column. Furthermore none of the wells drilled into the Comanchean Cretaceous, in East Texas and Louisiana has encountered bodies of salt or strata of appreciably saline nature. The source of this salt must, therefore, be probably more deeply seated than the Comanchean Cretaceous.

THE PRE-COMANCHEAN FLOOR.

Definite knowledge is lacking as to the age and nature of the rocks below the Comanchean Cretaceous floor in East Texas. It has been generally supposed that these overlying strata were of Pennsylvania age, but data recently obtained from widely separated localities, indicate the extensive occurrence there of "Red Beds"—like continental formations instead. If these Red Beds are the same as those which overlie the Pennsylvanian in West Texas (and there is no reason for supposing that they are not the same), and contain similar vast beds of rock salt, then it is not difficult to estimate the most probable source of the latter material beneath the Comanchean Cretaceous in East Texas.

There are good reasons for suspecting that the semi-continental Permian Red Beds of Western Texas with their great salt beds may extend beneath East Texas and Louisiana. These beds now occupy a great regional syncline in West Texas. This syncline passes on the east into a broad anticline, the arch of which is supposed to be approximately beneath Fort Worth. From thence eastward another great syncline begins beneath the Mississippi embayment.

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*Journal Franklin Institute, August-October, 1902.

**Univ. Texas Bulletin No. 1869, 1918, p. 308.

The summit of the Fort Worth Arch was truncated in Triassic or Jurassic time by pre-Cretaceous peneplanation and the Red Beds of Permian and later age, which, with the Pennsylvanian strata, composed it, were eroded away from the North Central Texas district. There is no logical reason for presuming, however, that the Red Beds were not preserved in the East Texas Syncline as well as that of West Texas. The salt of the salt domes in our opinion is contributory evidence to this hypothesis. (See Figure 26.)

According to Rogers* "the derivation of the European salt domes from a Permian bedded deposit now appears to be indisputable." It is very probable that similar conditions may yet be proven beneath the East Texas and Louisiana regions.

The Problem of Ascension.

Two hypotheses have been advanced dealing with the method of the ascension of the salt. One of these is by Mrazec,† a Bohemian are cited by Powers in the American Journal of Science, February, 1920, p. 140, and Rogers in American Economic Geology, Sept., 1918, pp. 466-467.

The first of these hypotheses would account for the disturbance of the adjacent strata, as will be presently further explained. The latter is supported by modern instances of the ascension of hot saline solutions seen in many deep wells. The crustification in the massive salt columns as seen in the deep shafts of the salt mines of Louisiana, is contributory testimony indicating that the salt of the domes may have ascended in solution. Three hypotheses have been advanced for the pushing up of the strata above and around the domes. One of these presumed that the softer and less consolidated upper strata have subsided around the top of the salt column. This is now known to be untenable. A second, propounded by G. D. Harris, implied that the doming had been caused by the expansion accompanying the crystallization of the salt from solution. The third theory, now much in favor, is that of Mrazec that the salt in a semi-plastic condition was pushed up through fissures as an extension of a great stratum of salt below and which, as he alleges, was the case with the salt formations along the south front of the Carpathians in Roumania which have been extensively studied by him. There, as in Texas, the salt column and some of its surrounding strata penetrate upward through the later beds as much as 7,000 feet at certain points on structural axes, originating a structure very much like our Texas domes, but more oblong in outline and occurring at certain points along definite anticlines. Perhaps it is to his conclusions that we may best look for the most plausible explanation of the Texas deposits, but with some as yet undetermined modification. This hypothesis of Mrazec's may be true, but like some obscurely propounded occult doctrine, it requires much further reflection before acceptance.

Notwithstanding the rapidly accumulating literature of the subject, the time is not as yet ripe for final deductions, and, as stated by Powers, "it is to be hoped that a careful digest and analysis of the hosts of unpublished information about salt domes will be forthcoming."‡

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*Economic Geology, Sept., 1918, p. 466.

†In various Roumanian publications, the principal ones of which geologist, who postulated that the salt may have been pushed up the fissures in a semi-plastic condition resulting from pressure. The second hypothesis is that the salt rose in supersaturated solution through hydrostatic pressure.

OIL IN THE SALT DOMES.

It is a peculiar incident that oil has thus far been found only in the 4,000 feet of Plio-Pleistocene strata around and over the salt domes of the Coastal belt.. The few tests around the interior domes of Texas and Louisiana, which penetrated the Woodbine and other Cretaceous sands, have proven barren with the exception of a few quarts of oil, found in one locality, such as might be found in the same strata at any other locality away from the domes.

The tests of the interior domes have been relatively few and unproductive but insufficient in number to condemn them. As stated by De Golyer,** "these tests prove nothing but the barrenness of the limited area on which they were drilled. Many of the salt domes of the Coastal Group had been prospected intermittently for years before production was found." Some of the Coastal domes like those of West Columbia, Damon and Goose Creek have required from 15 to 18 years experimentation before coming into production."

In the foregoing article by Mr. Hill, he presents the theory that the salt of the domes has been derived from beds below the Cretaceous in Texas and Louisiana, most likely the Permian. Accepting this theory, we have a plausible explanation of the seeming absence of salt domes east of the Mississippi River. There is no known occurrence of Permian in the southeastern states overlying either the Pennsylvanian or the older pre-Cambrian crystallines. On the other hand, the most recent pre-Cretaceous beds are of early Pennsylvanian age while from the dip of the Cretaceous sea floor of older crystalline rocks, it is quite evident that the land area of pre-Cambrian rocks was much greater during Paleozoic times than at present. By projecting the present contact of the Paleozoic pre-Cambrian we find that it will extend southwestward to the present delta of the Mississippi River, east of which no salt domes are known. It is not known that the crystallines directly underly the Coastal Plain this far southwest but there is no data to disprove it. Thus we find salt domes in areas west of the Mississippi River where it is most reasonable to expect the presence of Permian below the Cretaceous and upon which there have been gathered recently, data that uphold the theory. East of the Mississippi River in the near Coast area the possible presence of Permian strata cannot be accounted for between the Lower Cretaceous and pre-Cambrian rocks.

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‡American Journal of Science, February, 1920, p. 140.

**"The Journal of Geology," Nov.-Dec., 1919, p. 663.

To summarize: West of the Mississippi River, where the presence of Permian strata, which contain salt beds, is probable, there are numerous salt domes; east of the Mississippi River, where pre-Cambrian crystallines and Pennsylvanian rocks underly the Cretaceous, there are no salt domes. These conditions support the theory by Mr. Hill of the derivation of the salt from pre-Cretaceous beds and at the same time points to the unlikelihood of the presence of salt domes along the Eastern Gulf and Atlantic coasts.

POSSIBLE SANDS BENEATH THE COASTAL PLAIN.

The consideration of the sand horizons beneath the Coastal Plain of Alabama that might have possibilities of producing oil in commercial quantities is rather unsatisfactory, largely because of the lack of data concerning the subsurface formations over the areas that are considered to be the most promising. Several wells have been drilled in the extreme southern part of the State but none of them has been of sufficient depth to penetrate all of the strata within what is now considered to be the economical depth for thorough testing. On the Hatchetigbee Anticline two deep tests have been put down, one to 3,400 feet below the surface and the other to 4,013, which show all the strata from near the top of the Hatchetigbee formation through the Tuscaloosa, the lowest member of the Upper Cretaceous, and into what is probably the Comanchean, giving a fair idea of the subsurface beds in the southwestern portion of the State. East of the Alabama River few wells have been sunk to more than 1,C00 feet and therefore throw little light on the situation. In the absence of these definite data it becomes necessary to study the areas of outcrop of the various formations and compare them with the areas similar formations from which petroleum is being obtained in commercial quantities in other states.

The Tuscaloosa Formation.—This formation, which is the lowermost of the Upper Cretaceous or Gulf Series, outcrops as unconsolidated and cross-bedded sands, vari-colored clays and gravels. For more complete descriptions see the chapter on the Tuscaloosa and Lower Cretaceous beds under Areal Geology. The nature of the materials of the deposits and the structure of the beds show that they were deposited as continental or delta deposits. Frequent clayey portions of the formation contain abundant leaf impressions and some lignitic material which is evidence of the existence of a more or less luxuriant plant life. With the normal transitional sedimentation seaward or down the dip of the strata it would be expected that along the shore line of the Tuscaloosa sea there would be semi-marine or littoral deposits, succeeded in turn by predominating shales and clays and next calcareous materials. We are dependent on the logs of wells that have been drilled toward the present southern limit of the outcrop of the formation for information regarding the actually existing conditions.

The only wells that have penetrated strata that might be referable to the Tuscaloosa, except within a comparatively short distance of the outcrop, are the Bollinger No. 1, drilled by the Empire Gas and Fuel Co., in Section 13, Township 9 N., Range 3 W., on the Hatchetigbee Anticline northwest of Bladon Springs, Choctaw County and the Mitchell No. 1 in Clarke. The log of the former well is given on page 206. It will be noted that from the depth of 3,615 to the bottom of the well, 4,013 feet, all of the strata are logged as red "gumbo" or shale, except thin beds at the top and bottom of this portion of the vertical section. These strata occupy the stratigraphic position below the chalk of the Tuscaloosa but are here referred, because of the nature of the material, to the Comanchean or Lower Cretaceous which, if correct, shows that the Tuscaloosa has thinned considerably. Overlying the red beds there is a thickness of 460 feet of white and green sand that are considered to belong to the Tuscaloosa formation. The sand, shales and limestone from 2,790 to 3,176 are placed in the Eutaw formation and show from the formation outcrop a seaward transition from sands and marls to shales and limestone. These logs do not lend particular encouragement to the possibilities of the Hatchetigbee Anticline despite the fact that the structurally highest part of the fold has not been drilled below the Selma Chalk.

The Woodbine of Texas and Louisiana, which is productive in the latter state, is composed of littoral sands, clays and bituminous clays along its outcrops and largely of bituminous shales and clays with thin sand beds in the areas where it yields production. In these states red sands and clays have been found in some localities below the Woodbine horizon and in eastern Louisiana immediately below the chalk horizon which in that section is correlated with the Annona of east Texas. Some relationship between these red materials west of the Mississippi River and those penetrated in the Bollinger No. 1 suggests itself but at the present time the evidence is too meager to draw conclusions.

The Eutaw Formation, which is the time equivalent of the lower portion of the Austin Chalk of Texas and probably a considerable part of the Eagle Ford formation, immediately underlies the chalk in Alabama. The Tombigbee sand member of western Alabama and Mississippi occupies the stratigraphic position of the Blossom sand of northeast Texas and Arkansas and is probably very near the time equivalent. Along its outcrop the Eutaw consists of shallow water marine sands, clays and marls while in its upper portion in central and eastern Alabama it becomes very calcareous. Down the dip of the strata the horizon becomes more shaly, as indicated by the logs of several wells south of its outcrop, and seems to be following the normal depositional transition with variations in the form of sand beds. In a well drilled three miles south of Myrtlewood, Marengo County the Eutaw horizon contains considerable chalk inter-stratified with sand. Southward to the Bollinger well the excessive thickness of the chalk may be accounted for by the transition of Eutaw sands into limestone. In that case the sands below the chalk and over the red beds are referable to the Tuscaloosa formation as suggested above.

The writer was present when the well near Myrtlewood was being tested for water and found it to produce on the pump five gallons per minute of salt water that seemed to be a 25 per cent or more saturated solution with considerable gas escaping from the hole. There was also a rainbow on the water, which the driller insisted came out of the well, but which might have been either from the pump or tools. A log of the well as reported by the driller with formational subdivisions is given on page 203. This log shows a 75-foot bed of blue shale that is the probable source of the little gas and possibly the oil if it actually comes from the well. The Blossom sand and containing horizon in Louisiana is composed of blue shales and clays with thin beds of sand carrying oil on some of the structures drilled.

The Selma Chalk is in its lower part equivalent in time of deposition as well as lithologic character to the Annona chalk of Louisiana. This horizon is productive in the Caddo field in the latter state, and it is interesting to note that showings were found in the Selma Chalk in the Mitchell No. 1 well on the Hatchetigbee Anticline and a well drilled on the Jackson Anticline near Jackson, Miss. In Louisiana the Annona has most likely been made productive by migration from a lower horizon. It is unlikely that the phenomenon will be repeated in Alabama.

The Ripley Formation, which in eastern Alabama has a thickness of nearly 1,000 feet, occupying the entire Selma-Ripley horizon, thins to the westward and disappears in the vicinity of the Tombigbee River. In the Alabama River section it has a thickness of 270 feet and south of Union Springs it is composed of some 450 to 500 feet of the typical beds. The materials along the outcrop of the formation are clear quartz sands, glauconitic and black argillaceous sands, clays, shales and marls. In a few localities the marls are indurated and act as the supporting medium for a rather rugged topography. The outcrop is described more fully under formation descriptions. Except in the southwestern part of the State no wells of which we have record have been drilled into the Ripley strata at any considerable distance from the surface terrane of the formation so that we have no knowledge of the character of the materials down the dip from the outcrop, except as mentioned below. The strata exposed are of near shore marine deposition, and with the normal transition a zone of predominating shale should be expected at some distance from the old shore line and next, with favorable conditions of sedimentation, calcareous materials. Whether or not these shales, if present, are bituminous and contain sands that might act as containing mediums for any petroleum which might have originated in the shales can only be told by the drilling of test wells. Any remarks that might be made regarding the possibilities of the sands would only be hypothetical. In the area of the Hatchetigbee Anticline where the only deep tests in southern Alabama have been made, the Ripley is missing or is present as shales and "gumbo" as shown by the Bollinger No. 1, and the Mitchell No. 1, the logs of which are given.

The Ripley is the stratigraphic and time equivalent of the Navarro formation of Texas which is, in turn, the depositional equivalent of the Arkadelphia clay of Arkansas. This latter formation contains the Nacatoch sand, one of the productive horizons of northern Louisiana. Along its outcrop the Ripley is quite similar in lithologic character to the Navarro, they both being near shore marine deposits. Away from the outcrop of the Navarro the sediments change to predominating shales and clays similar to the exposed beds of the Arkadelphia. The logs of practically all the wells which have penetrated these formations away from their outcrops show the fine sediments to be black in color. No well data are available in Alabama by which an idea of the character of the Ripley down the dip from the surface terrane can be obtained.

From the character of the Ripley surface materials, their stratigraphic position and their thickness in the central and eastern parts of the State, it seems that the Ripley sands have probably the most promising outlook for the production of petroleum in commercial quantities of any of the strata which compose the Coastal Plains sediments in Alabama. As yet no showings or gas have been found in this horizon but at the same time no wells are known to have penetrated the beds and probably have not except as above mentioned.

The *Tertiary strata* have been penetrated in quite a number of localities in the southern part of the Coastal Plain with showings of oil and a little gas reported in a few wells. On the Hatchetigbee Anticline and near by several wells that were drilled fifteen to twenty years since report in the logs that comes from the Tertiary horizons. The Roberts well in Escambia County (see log, page 211) reports several showings of oil and gas. It is improbable that any of these wells were drilled on structure with the exception of the Hatchetigbee Anticline tests. The materials of the Tertiary are predominating shales and clays with thick beds of limestone and sand horizons of lesser vertical extent. The shales are generally blue to black in color. In Texas and Louisiana where these beds are penetrated there are frequent showings of oil, while a little gas is the rule rather than the exception. However, little or no production has been obtained from any of the Tertiaries with the probable exception of the salt domes along the Gulf Coast and in southwest Texas, where some oil and considerable gas is derived from the horizons above the Cretaceous.

POSSIBILITIES IN THE COASTAL PLAIN BY AREAS.

The Coastal Plain of Alabama is in this report subdivided into five areas in which the prevailing conditions are either alike, based on the content of the sands, the depth to the impermeable horizons, the nature of the beds underlying the surface materials, the structural conditions and the possibilities of working out the structural deformations in the surface. In certain fields there are beds underlying the surface materials that have a possibility of producing oil in [illegible] fresh water, while in other [illegible] be favorable but the [illegible] determined on the surface. [illegible] wells drilled in the south- [illegible] salt water in numer- [illegible] the dip of the strata these [illegible] quantities of [illegible] water show a gradual in- [illegible] a point [illegible] these va- [illegible] because of the [illegible] and the [illegible] have been [illegible] in the [illegible]

[illegible]

Area 5.—This subdivision of the Coastal Plain embracing Hale and Perry Counties and the adjacent portions of Tuscaloosa, Bibb, Marengo, Sumter and Greene is covered along its northern half by a rather thin blanket of Tuscaloosa sands and clays under which lie the highly folded and faulted Paleozoic strata of the Valley Region. In the Tuscaloosa sands there are fresh waters only, while the underlying Paleozoics have been subjected to such metamorphism that the possibilities of commercial deposits of petroleum do not look very encouraging. The southern part of the area is overlain by the Selma Chalk while the underlying Cretaceous sands carry fresh or very slightly saline waters which is indicative of free circulation of the liquids and consequent escape of any petroleum that might have been present. No structure of consequence is known in the area.

Area 6.—Eastward from the above mentioned area there is a district of similar conditions composed of Autauga, Elmore, Montgomery, Macon, Russell, Bullock, Lowndes and Dallas Counties and the adjoining parts of Chilton and Lee on the north and Barbour and Pike on the south. The northern part of this belt is covered by sands and clays of the Lower Cretaceous series from which the nature of the materials and the fresh water content do not offer possibilities of the presence of oil. Underlying the Lower Cretaceous beds are the basement rocks of the metamorphosed Pre-Cambrian Piedmont Region, which are not petroliferous. The southern part of the belt is covered with Selma Chalk underlying which are sands and clays of the Eutaw, Tuscaloosa and Lower Cretaceous formations. All of these sands are fresh water-bearing and cannot be expected to contain deposits of petroleum in commercial quantities.

Area 7 extends as a belt across the entire State, including within its limits all of Choctaw, Clarke, Wilcox, Monroe, Butler, Crenshaw, Coffee, Geneva, Dale, Henry and Houston Counties, the southern halves of Sumter, Marengo, Pike and Barbour Counties and the northern parts of Washington, Conecuh and Covington Counties. This belt is underlain by all of the sands discussed under the heading of "Possible Sands Beneath the Coastal Plains." Also it is the area where are found all the known folds and faults of the Coastal Plain that might be favorable accumulation areas. Except along the extreme northern edge of the area all of the sands contain salt water while numerous gas and some oil showings have been reported in the logs of several wells drilled. In the western part of this area the Ripley formation, which is one of the most promising of the Coastal Plain, is missing, or contains no sand, while below the chalk there is mostly sand for the upper 400 feet and then red beds as far as the drill has penetrated. From the Alabama River eastward the Ripley is present and increases to a maximum thickness of near 1,000 feet. In the extreme eastern part of the State the Selma-Ripley horizon is occupied entirely by the above thickness of Ripley material, there being no chalk, and seems to be the area of greatest possibility.

Area 8 comprises all of those counties south of the above described group, namely, Washington, Mobile, Baldwin, Escambia and the southern parts of Conecuh and Covington. In this district it is probable that the same conditions obtain as far as the sands are concerned as in the area to the north except that the horizons are deeper in accordance with the dip of the strata, and maybe contain fewer sands. Also there is a greater thickness of Tertiary formations to be penetrated which may or may not have possibilities of yielding oil. The nature of the surface sands precludes the possibility of determining the structural conditions; therefore, locations in the area must be made more or less blindly. This is the corresponding area to the Coastal salt dome belt in Louisiana and Texas, but as far as known none exists in Alabama. This point is discussed under "Structure."

DEPTHS TO SANDS.

The most promising formations below the Geneva Anticline, in Geneva County, are the Ripley and the Eutaw. It is not known if the Tuscaloosa is present below these formations but from the presence of the lower part of the Upper Cretaceous in west Alabama and Georgia, it is most likely present here also. Eastward from Wetumpka the Tuscaloosa is overlapped by younger formations. The nature of the Lower Cretaceous beds which unquestionably underly the southeastern corner of the State cannot be told though south of Tallahassee, Florida, it is reported that Lower Cretaceous limestones have been penetrated by the drill, while along its outcrop it consists of continental deposits. The depth to the top of the Ripley, based on the thickness of the formations along their outcrops should be in the neighborhood of 1,200 feet. If the thickness of 1,000 feet obtains this far south, the base of the Ripley will be found at 2,200 feet, below which there should be several hundred feet of strata referable to the Eutaw formation, underlying which either Lower Cretaceous or strata of Tuscaloosa age should be encountered at from 2,500 to 2,800 feet. These depths to the formations containing the most likely sands are referable to those areas in the southeastern portion of the State in which the Claiborne formation is exposed.

On the Lower Peachtree Anticline, west of the river, the drill would begin very near the top of the Tuscahoma formation. It is estimated that the top of the Ripley will be encountered at about 750 feet with a thickness of 270 feet, which obtains in the nearest area of outcrop. The base of this formation, or the top of the chalk, would be struck at 1,020 feet after which would come a thousand feet of Selma Chalk. The drill should enter the Eutaw at 2,020 feet, estimating a thickness of 300 feet, the Tuscaloosa should be encountered at approximately 2,300 feet. The Bollinger No. 1, on the Hatchetigbee Anticline, shows about 400 feet of sands referable to the Tuscaloosa, underlying which are drill penetrated to the bottom of the well over 400 feet of Red Beds. These depths are referable to those areas over which the Tuscahoma formation comes to the surface.

DEVELOPMENT.

The first recorded drilling for petroleum in Southern Alabama was the Cullom Springs well near Mladon Springs on the Hatchetigbee Anticline in 1884-85. This test was watched by D. W. Langdon, then of the Alabama Survey, who determined Selma Chalk at 1,220 feet below the surface. The test was abandoned after the chalk had been penetrated for a short distance. After the discovery well was brought in near Beaumont, Texas, several wells were drilled in the vicinity of Mobile, and one near Roberts, in Escambia County. In 1917-18 a well was drilled to a depth of 3,400 feet by the Alahoma Oil Company in Section 26, Township 8 N., Range 1 W., on the Hatchetigbee Anticline in Clarke County. Later, in the spring and summer of 1918, the Empire Gas and Fuel Company drilled their Bollinger No. 1 to a depth of 4,013 feet in Section 13, Township 9 N., Range 3 W., also on the Hatchetigbee Anticline in Choctaw County. Most of these wells drilled in southern Alabama have reported gas and small showings of oil, but no production of commercial value has been obtained up to the present time. Numerous wells in the Coastal Plain of Alabama have been drilled for the purpose of securing fresh water for industrial and domestic uses. A great many of these wells, particularly north of the seaward limit of the Selma Chalk, have given the information regarding the subsurface conditions. Along the southern edge of this belt the artesian waters are generally saline and frequently have small showings of gas.

WELL LOGS.

On the following pages the logs of several wells drilled in the Coastal Plain of Alabama for oil and water with the formational subdivisions, where practicable, are given. In three wells drilled in the Hatchetigbee Anticline the Mitchell No. 1, to the east, encountered the Selma Chalk at 1,700 feet below the surface, the Cullom Springs well near Bladon Springs at 1,220 feet, and the Bollinger No. 1, near the western limit of the Hatchetigbee formation inlier, at 1,980 or possibly 1,880 feet. The log of the Bladon Springs well found the Chalk at the elevation calculated from the thickness of the formation along their outcrops to the north while the Mitchell No. 1 encountered it at the depth that would be expected without the presence of the structural uplift. The Bollinger No. 1 found the horizon still lower than the undisturbed normal dip of the formation would place it in this area.

If these logs are correct, there is a structural high in the Selma Chalk at Bladon Springs, while the chalk beneath the other two well areas does not conform to the surface structure of the Hatchetigbee Anticline. This renders the correlation of the strata above the chalk impracticable without having cuttings from the wells.

WELL RECORDS

Log of Well at Gunnet Bros. Lumber Company Mill

2½ miles southeast Myrtlewood, Marengo County, N.E. ¼ Section 29,
Township 14 N., Range 2 East. Elevation 270 Feet?
Drilled March, 1920.

	Top Feet	Bottom Feet
Sucarnochee Formation:		
Soil	0	12
Soapstone (clay)	12	140
Clayton Limestone:		
Soapstone (limestone)	140	180
Selma-Ripley:		
Soapstone (chalk)	180	220
Soapstone (clay)	220	450
Soapstone (chalk)	450	700
Soapstone, very sticky (chalk?)	700	1055
Hard white rock (chalk)	1055	1099
Soft soapstone (chalk)	1099	1225
Hard blue rock (chalk)	1225	1300
Blue shale (chalk?)	1300	1375
Eutaw Formation:		
Flint rock (gas)	1375	1376
Fine-grained sand (water)	1376	1381
Blue chalk	1381	1387
Hard rock	1387	1388
Sand and broken shells	1388	1407
Rock, very hard	1407	1418
Fine white sand (water)	1418	1446
Flint (bottom of well)	1446	1449

Well supplies 5 gallons per minute of 25% saturated solution salt water. First gas struck at 1,375. Considerable gas escaping at time of writer's visit. A rainbow showed on water while well was on the pump that driller insisted came from well. May have been from tools, however.

Well of Camden Cotton Oil Company, Camden, Alabama.

	Thickness Feet	Depth Feet
Strata:		
Sand and gravel	10	10
Soapstone, laminated clay and shells	18	28
Rock	3	31
Soapstone	133	164
Ripley Formation:		
Flint rock	1	165
Lime rock	18	183
Hard rock	1	184
Sand and water	16	200
Hard rock	1	201
Clay	3	204
Sand rock	9	213
Clay	2	215
Hard rock	1	216
Lime rock?	92	308
Hard rock	8	316

Sand, shells and good stream water	34	350
Hard rock	1	351
Black dirt and good quantity mica	32	383
Flint rock	1	384
Selma chalk:		
Lime rock	146	530
Blue clay	20	550
Lime rock	245	795
White clay	38	833
Black dirt	83	916
Hard rock	2	918
Lime rock	232	1150
Blue clay	23	1173
Sand and some water	22	1195
Lime rock	40	1235

Mitchell No. 1, Alahoma Oil Company, Salitpa, Clarke County, Alabama.

S. 26, T. 8, R. 1 W.
Authority: W. C. Roark.
Contractors: J. M. Eastham, Battle House, Mobile.
Rotary Driller, W. C. Roark.
Dates: Commenced October 6, 1917; finished January 29, 1918.

	Top Feet	Bottom Feet
Tertiary:		
Clay, red, hard	....	8
Sand, brown, soft	8	60
Shale, Gumbo, brown, soft	60	300
Rock, gray, hard	300	302
Gumbo, boulders, brown, hard	302	340
Gumbo, blue, medium hard	340	380
Rock, black, hard	380	381
Shale, gray, soft	381	400
Gumbo, blue, soft	400	470
Gumbo, blue, hard	470	520
Shell, white, hard	520	525
Shale, gray, soft	525	575
Gumbo, blue, medium	575	610
Shale, gray, soft	610	680
Gumbo, blue, hard	680	700
Gas rock (coarse S). brn. hd.	700	707
Show of gas.		
Shale, gray, soft	707	750
Gas rock, brown, hard	750	756
Hard coarse sandstone (gas showing).		
Gumbo, blue, medium	756	800
Shale, gray, soft	800	860
Shell, white, medium	860	870
Gumbo, blue, hard	870	910
Gumbo, blue, hard	910	945
Sandstone, black, hard	945	950
Shale, blue, soft	950	1010
Shell, white, hard	1010	1015
Shale, blue, soft	1015	1090
Gumbo, blue, hard	1090	1100

Rock, black, flint, hard	1100	1103
Shale, blue, soft	1103	1160
Gumbo, blue, soft	1160	1200
Rock, black, hard	1200	1202
Shale, blue, soft	1202	1300
Ripley formation:		
Rock, black, hard	1300	1304
Gumbo, blue, soft	1304	1360
Shale, blue, soft	1360	1400
Shale, gray, soft	1400	1520
Gumbo, blue, soft	1520	1600
Shale, gray, soft	1600	1640
Gumbo, blue, hard	1640	1700
Selma chalk:		
Chalk, rock, white	1700	2650
Eutaw formation:		
Little sand, soft Salt water.	2650	2660
Shale, white, soft	2660	2680
Gumbo, gray, soft	2680	2700
Shale, gray, soft	2700	2720
Shale, boulder, gray, soft	2720	2746
Sand, white, soft Very fine salt water.	2746	2766
Rock, black, medium (looks like sandy shale)	2766	2769
Gumbo, blue, medium	2769	2781
Shale, gray, soft (supposed to be top Woodbine Sand)	2781	2800
Sand, white, soft Very soft, with hard spots.	2800	2820
Shale, gray, soft	2820	2840
Tuscaloosa formation:		
Sand, green, medium	2840	2920
Sand, white, medium	2920	3007
Shale, gray, soft	3007	3027
Sand, light brown, medium	3027	3055
Shale, gray, soft	3055	3080
Gumbo, blue, tough	3080	3090
Sand, light brown, soft Soft, with hard spots. Salt water.	3090	3130
Shale, gray, soft	3130	3148
Rock, hard (Pyrites)	3148	3150
Shale, gray, soft	3150	3155
Rock, brown, hard	3155	3157
Sand, white, soft	3157	3191
Gumbo, blue, soft	3191	3202
Sand, white, soft	3202	3233
Shale, gray, soft	3233	3279
Gumbo, blue, hard	3279	3300
Shale, gray, soft	3300	3336
Sand, white, soft	3336	3396
Shale, gray, soft	3396	3400
Total depth		3400

Only small showings reported.

Derrick 112 feet high.

According to the log of the Mitchell No. 1, this well had almost reached the "Red Beds."

Bollinger No. 1, Empire Gas & Fuel Co., Choctaw County, Alabama.

Location: Section 13, Township 9 N., Range 3 W.
Drilling: March 28, 1918; May 16, 1918.
Casing record: 10-inch, 97 feet; 8-inch, 1142 feet; 6-inch, 2,856 feet.

	Thickness Feet	Bottom Feet
Tertiary:		
Clay, red, hard	8	8
Sand, brown, soft	15	23
Rock, blue, hard	7	30
Flint, very hard.		
Shale, blue, soft	110	140
Rock, brown, medium	5	145
Shale, blue soft	65	210
Gumbo, blue soft	80	290
Rock, black, hard	12	302
Gumbo, blue, soft	110	412
Shale, gray, soft	148	560
Sandy shale, brown, soft	90	650
Rock, black, hard	2	652
Gumbo and shale, blue, soft	98	750
Gumbo and shale, blue	90	840
Sand, green, soft	60	900
Fresh water flow.		
Shale, gray, soft	120	1020
Sand, white, hard	100	1120
Gumbo, blue, soft	22	1142
Gumbo, blue, tough	20	1162
Sandy shale, gray, soft	180	1342
Rock, brown, hard	2	1344
Gumbo and shale, gray	65	1409
Shell, white, medium	8	1417
Gumbo and shale, blue	90	1507
Shell, white, hard	12	1519
Gumbo and shale, gray	80	1599
Rock, black, hard	1	1600
Gumbo, blue, tough	30	1630
Ripley formation:		
Sandy shale, gray	120	1750
Sandy shale, gray	120	1870
Shell, white, medium	10	1880
Gumbo and shale, white	100	1980
Selma chalk:		
Chalk, rock, white, hard	40	2020
Chalk rock, white, medium	80	2100
Chalk rock, white, medium	120	2220
Chalk rock, white, hard	110	2330
Chalk rock, white, medium	110	2440
Chalk rock, white, hard	60	2500
Chalk rock, white, hard	60	2560
Chalk rock, white, soft	140	2700
Chalk rock, white, soft	80	2780
Chalk rock, white, hard	10	2790
Eutaw formation:		
Sand, white, soft	15	2805
Salt water.		
Gumbo, blue, tough	51	2856

Material	Thickness Feet	Depth Feet
Gumbo, blue, tough	15	2871
Shale, white, soft	20	2891
Shale, gray, soft	25	2916
Limestone, white, soft	10	2986
Very soft with hard brown spots.		
Lime, white, soft	160	3146
Very rotten.		
Shale, white, hard	10	3156
Shale, brown, soft	20	3176
Tuscaloosa formation:		
Sand, green, soft	59	3235
Sand packed	30	3265
Salt water show.		
Sand rock, white, hard	4	3269
Sand, white, soft	60	3329
Sad rock, white, hard	9	3338
Sand green	55	3393
Salt water flow.		
Sand, green, hard	40	3433
Sand, white, medium	50	3483
Gumbo, blue, tough	12	3495
Sand, white, hard	60	3555
Sand, white, very hard	60	3615
Lower Cretaceous (?):		
Sand, redish, hard	15	3630
Gumbo, red, tough	25	3655
Shale, red, hard	55	3710
Shale, red, medium hard	30	3740
Gumbo, red, tough	10	3750
Shale, red	55	3805
Gumbo, red, tough	20	3825
Shale and gumbo	50	3875
Very broken.		
Gumbo, red, tough	10	3885
Shale, red, hard	30	3915
Shale, red	25	3940
Shale, red	20	3960
Gumbo, red	15	3975
Shells	10	3985
Shale, red	20	4005
Sand, very hard	8	4013
T. D.		

Record of Cullom Springs boring.

Hatchetigbee formation:		
Loose surface materials, varying slightly in color and texture	80	80
Alterations of blue and sandy marl (clay), with indurated blue ledge 5 feet thick at base	81	161
Soft clayey marl	23	184
Bashi formation:		
Greensand, with shells, 3 feet, followed by 22 feet alternating hard and soft beds, the latter fossiliferous and water bearing	25	209
Marls or blue clays	46	255

Material	Thickness Feet	Depth Feet
Brown and blue marls (clays) in many alterations (lignitic?)	21	276
Tuscahoma formation:		
Blue marls or clays, with 2 feet of greensand at base	61	337
Lignite, 5 feet, followed by 19 feet of brown, tough marl (clay)	24	361
Blue sandy marl, with many varieties of shells; Venericardia planicosta recognized	23	384
Blue, sandy marl (clay)	58	442
Brown marl (clay), 5 feet, with 32 feet blue marl below	37	479
Greensand marl, 9 feet, followed by 37 feet of blue marl (clay); at 500 feet water was struck which flowed 10 feet above the surface	46	525
Nanafalia formation:		
Brown clay marl, 19 feet, followed by 15 feet of blue clay with greensand, containing shells	34	559
Brown marl, resembling soapstone; contains shells; stream of water near bottom which flowed 30 feet above surface	50	609
Gray sandy marl, with shells	15	624
Gray sandy marl, with shells; more clayey than preceding	64	688
Very tough blue marl (clay), at base of which is a thin layer of white sand and then a thin layer of greensand	71	759
Naheola formation:		
Brown marl (clay), 5 feet, followed by alternating beds of clay and sand, mostly sand first salt water)	20	779
Alternations of gray and brown sand, with marl (clay)	26	805
Tough blue marl (big vein of salt water)	13	818
Sand and clay alternating	14	832
A kind of white limestone (?) containing mica, passing below into 3 feet of blue sandy marl, containing shells	28	860
Blue marl (clay), 14 feet, followed by 14 feet of blue marl and sand, numerous shells	28	888
Marl 12 feet, with streaks of sand, followed by brown sand and marl, 12 feet	24	912
Sucarnochee and Clayton formations:		
Greenish rock, chalky above, hard below	11	923
Sandstone, 4 feet, followed by 25 feet of white, blue, and gray quicksand (strong stream of salt water)	29	952
Marls or clays, mostly grayish or light brown, with several ledges of extremely hard rock, e. g., one 2 feet thick at 966 feet, one 1 foot thick at 971 feet, one 3 inches thick at 978 feet, one 1 foot thick at 1,000 feet	137.	1089
Ripley formation:		
Tough black clay, 2 feet, followed by 99 feet of dark blue clay, some of it quite hard and firm, some very soft and sticky	101	1190

Material	Thickness Feet	Depth Feet
Snuff-colored clay, soft and sticky	13	1203
Gray sand and shells, 12 feet, followed by 5 feet of soft sandy clay	17	1220
Selma chalk:		
Hard ledge, 4 inches thick at top, below which are about 125 feet of moderately hard grayish or blue rock, with scarcely any change in color or texture, to bottom of boring; no shells observed; "Rotten limestone"	125	1345

The following additional notes regarding this well may be of interest: At 80 feet water was struck, but it did not overflow. At 200 feet there was a bold stream of mineral (vichy) water, which overflowed. At 400 feet another strong stream of mineral water, like the preceding. At 1,000 feet a stream of salt water with inflammable gas was struck. The present flow combines the streams at 200, 400, and 1,000 feet. The water is decidedly salt, and has a temperature of 83°. The gas collects in bubbles or in a foam on the surface of the water in the tank into which the stream flows. A lighted match touched to this foam ignites the gas, which burns over the surface of the water for some minutes, unless extinguished by accidental splash. The gas may also be ignited at the spout, where it burns with a flame 6 or 8 inches high. The estimated flow is 10 to 15 gallons per minute.

Log of Mobile Oil Company, No. 1 Well, Coden, Alabama.

	Top Feet	Bottom Feet
Upper soil	0	15
Blue clay	15	25
Lignite	25	27
Blue clay and sand	27	102
Coarse white sand	102	117
Gravel	117	152
Stiff blue clay	152	174
Blue sand	174	180
Blue shale and shells	180	202
Blue clay	202	254
Sand	254	259
Blue clay	259	274
Coarse white sand	274	320
Blue shale and shells	320	340
Blue shale	340	375
Sandstone	375	378
Gravel	378	379
Gumbo	379	394
Blue sand	394	404
Blue shale	404	409
Blue sandy clay	409	454
Blue clay	454	477
Sand	477	492
Blue shale	492	521
Sand	521	531
Blue shale	531	571
Gravel	571	576
Blue shale	576	626

	Top Feet	Bottom Feet
Blue shale and shells	626	628
Blue clay	628	648
Sand	648	670
Blue shale and lignite	670	672
Blue shale and rotten shells	672	692
Sand and shells	692	712
Shale	712	731
Gumbo	731	751
Shale and shells	751	771
Shale and small shells	771	780
Blue clay	780	810
White sand	810	815
Gumbo	815	840
Sand, salt water and gas	840	899
Gravel	899	946
Gray clay	946	967
Blue clay	967	984
Shale and shells	984	1007
Sand	1007	1030
Blue clay	1030	1059
Blue shale	1059	1070
Blue clay	1070	1092
Conglomerate pebbles	1092	1094
Hard blue shale	1094	1110
Sand rock	1110	1112
Gumbo	1112	1148
Sand rock	1148	1153
Gumbo	1153	1156
Sand rock	1156	1164
Gumbo	1164	1169
Sand rock and gas	1169	1173
Blue clay and lignite	1173	1196
Hard rock	1196	1200
Gumbo	1200	1212
Rock	1212	1214
Gumbo and lignite	1214	1224
Rock	1224	1231
Fine sand	1231	1236
Rock	1236	1238
Blue clay and shell	1238	1246
Gumbo	1246	1258
Shale	1258	1283
Rock	1283	1285
Gumbo	1285	1308
Shale	1308	1353
Gumbo	1353	1438
Limestone, blue	1438	1440
Limestone and shale	1440	1452
Lime rock	1452	1459
Sand and shells—gas and salt water	1459	1519
Limestone	1519	1526

T. D .

ROBERTS.

The deepest boring made in Escambia County is a well bored for oil on the banks of Conecuh River, 6 miles above Roberts. Unfortunately samples of the materials penetrated at different depths could not be obtained except in a few instances. At a depth of 100 feet the St. Stephens limestone was struck, and the boring was still in the same rock at the depth of 190 feet. Claiborne shells were brought up in abundance before the drill had gone 700 feet. As nearly as can be determined the boring must have gone to the base of the Tertiary, if not into the Ripley beds.

A great volume of water was struck at less than 700 feet. It was estimated that, when half shut off, this flow was 3,000 gallons per minute, and much greater before being reduced.

The boring was done by M. Canfield in 1902-3. The Grand Gulf sands are at the surface, and the lower part of the river bluff is formed by the calcareous sands of Miocene age, while the top of the St. Stephens limestone is not far below the water level in the river, since it shows in the banks a few miles upstream. The water which pours out of this well is beautifully clear and blue, such as is seen in limestone springs, and is decidedly limy.

The record as given by Mr. Canfield is as follows:

Record of Well at Roberts.

	Feet	Feet
Sand	0	22
Blue marl	22	37
Fine white sand	37	39
Gumbo	39	60
Lime rock and shell	60	61½
Gumbo	61½	90
Layers of shell rock and blue clay, 1 or 2 inches thick	90	90
Blue clay, 1 foot; white shell rock, 2½ feet; blue clay, shell rock, 5 feet; very hard flint rock, 6 inches; soft lime rock, 2 feet; blue clay, 2 feet	100	113
Lime rock	113	120
Hard lime rock, 18 inches; soft lime rock, 2½ feet; hard lime rock, 2 feet	120	126
Lime rock; small slow at about 150 feet	126	234
Lime and sand shale (water)	234	248
Sand rock	248	317
Lime and sand (water)	317	337
Hard sand rock (water)	337	347

	Feet	Feet
Black muck, green clay, lignite, trace of oil; strong flow of water (3,000 gallons per minute)*	347	353
Lime rock, lignite, oily sand	353	363
Shale	363	365
Sandy shell rock	365	375
Shell rock	375	388
Sandy shale	388	401
Soft, honeycombed lime rock	401	413
Gumbo (sea sediment)	413	416
Hard shell rock	416	427
Soft sand rock, lignite	427	441
Lignite	441	446
Sand	446	466
Soft lime rock, becoming harder	466	480
Honeycombed lime rock (water)	480	490
Hard lime rock	490	505
Blue marl	505	506
Lime rock	506	522
Soft lime	522	524
Sand, strong flow of water, nearly as great as that at 350 feet	524	526
Lime rock, sandy at times	526	588
Sandy shale	588	600
Lime rock, part shells	600	629
Blue sand shale	629	639
Lime rock	639	653
Sand and shale; at 675 feet good flow of water	653	698
Lime rock; thin stratum of coal in last 30 feet	698	748
Shell rock (cap rock)	748	758
Sand rock, much mica	758	764
Shell rock	764	773
Hard slate	773	813
Shell and lime rock	813	821
Sand	821	831
Shell and sand	831	911
Pyrite	911	912
Blue marl	912	923
Gumbo, some shell	923	958
Chalk	958	960
Gumbo	960	968
Soft sand rock	968	988
Sand rock	988	992
Pyrite	992	999
Gumbo, streaks of shale	999	1148
Dark clay	1148	1154
Hard lime rock, shells	1154	1158
Clay, like lime	1158	1159
Lime, shells, sand rock	1159	1164
Gumbo, some gas	1164	1214
Porous lime rock	1214	1220
Shale	1220	1240
Soft, porous black rock, oil sand	1240	1245
Dark shale	1245	1290
Dark green sand	1290	1305

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*The water from 350 feet came up through a 12-inch pipe 22 feet above the ground, then 8 feet through a 4-inch pipe, in all 30 feet. From the top of this pipe a 4-inch stream was projected 35 feet into the air, 65 feet above the ground surface.

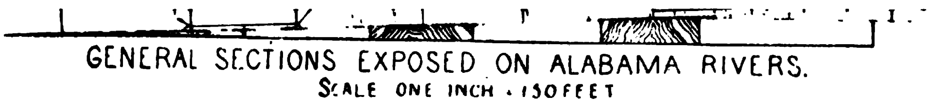
GENERAL SECTIONS EXPOSED ON ALABAMA RIVERS.
SCALE ONE INCH = 150 FEET

FIG. 27.

	Feet	Feet
Soft rock	1305	1310
Dark shale	1310	1320
Gumbo with shell	1320	1337
Soft sand rock	1337	1350
Dark shale	1350	1355
Shells, lime rock	1355	1360
Dark shale	1360	1375
Soft sand rock	1375	1380
Dark shale	1380	1390
White clay	1390	1400
Soft sand rock, black specks	1400	1410
Sandy shale, black specks	1410	1422
Dark shale	1422	1439
Pyrites, shells, sand and rock mixed together, salt water, flow 150 gallons per minute	1439	1484
Dark shale, hard streaks and some shells	1484	1522
Dark clay or gumbo	1522	1550
Hard flinty rock	1550	1553
Gumbo shale, some shells	1553	1640

At this depth the formation should be lower Nanafalia or Naheola. At 1300 feet a petrified sea-crab shell was found.

At 1600 feet, salt water about 200 gallons per minute.

General Section exposed along the Alabama Rivers.

From Coastal Plain Report.
Figure 27, Column 1, *Tombigbee River.*

1. Vicksburg. White Limestone with *Orbitoides mantelli*, forms upper 70 feet of Saint Stephens Bluff, upper part of Baker's Hill, and greater part of river bluffs down to Oven Bluff .... 140 feet
2. Jackson. Argillaceous White Limestone lower part of Saint Stephens and Baker's Bluffs .... 60 feet
3. Scutella beds, underlaid by coarse greensand and Claiborne fossiliferous sands .... 15 feet
4. Yellowish gray, calcareous sands, with *Ostrea sellaeformis*, clayey in part, traversed by hard, sandy ledges, greensand, with comminuted shells at base .... 35 feet
5. Bluish clay .... 7 feet
6. Aluminous sandstones, claystones, etc., of jointed structure, forming at White's Bluff a perpendicular cliff .... 115 feet
7. Brown clays, sandy, non-fossiliferous, 30 feet, followed by 3 feet marl and 15 feet purplish brown, sandy clays; then 28 feet of sands striped with brown clays and inclosing two beds with marine shells; in all .... 75-76 feet
8. Dark gray, sandy clays, striped with brown or purple, sandy clays. Very few fossils exposed at Davis's Bluff, White's Bluff and McCarthy's Bluff .... 100 feet
9. Clayey marl, passing into a greensand marl 18 feet thick (Wood's Bluff marl) .... 31 feet
10. Gray, clayey sands, with four or more thin seams of lignite .... 25 feet
11. Laminated sands and indurated sands, with boulders .... 30 feet
12. Gray, sandy clays, striped with somewhat harder, projecting ledges .... 35-40 feet

13. Greensand marl (Bell's Landing) 7 feet
14. Sandy, laminated clays 15 feet
15. Gray, sandy clays, rather thin bedded; hard, sandy ledge at base 28 feet
16. Glauconitic sands and clays, with *Gryphaea thirsae* 18 feet
17. Glauconitic sands, with *Gryphaea thirsae*, at Lott's Ferry, Eureka Landing, and Nanafalia Landing 35 feet
18. Black clay, passing into a greensand marl, with *Gryphaea thirsae* 18 feet
19. Black, micaceous, glauconitic sands 15 feet
20. Lignite 7 feet and 5 feet gray clay below 12 feet
21. Gray, sandy clays, cross-bedded sands and laminated clays in many alterations 80 feet
22. Greensand marl (Naheola), with black clay below 20 feet
23. Between Naheola and Black Bluff, black clays, thickness unknown.
24. Yellowish clays 30 feet, underlaid by 50 feet of black and dark brown, slaty, fossiliferous clays, Black Bluff fossils 80 feet
25. Dark blue or black, sandy clays, with indurated bands, calcareous below, passing into an argillaceous limestone 16 to 18 feet, with phosphatized shell casts (Ripley) 55 feet
26. Argillaceous limestone, with hard ledges, holding many shells (*Ostrea*, *Exogyra*, *Gryphaea*) (Rotten Limestone) 1,000 feet
27. Hard, calcareous sands, highly fossiliferous, 6 to 8 feet; thin, yellow, cross-bedded sands, 15 feet; and below this a phosphatic greensand, 8 to 10 feet About 25 feet
28. Cross-bedded, glauconitic sands with thin clay partings, yellowish color prevailing 40 feet
29. Dark gray, laminated, sandy clays, alternating with bluish sands 15-20 feet
30. Laminated sands and clays, alternating with cross-bedded sands 40(?) feet
31. Compact, micaceous sands, cross-bedded sands, laminated clays in many alternations, including two small beds of pebbles and thin bed of lignitic matter 60(?) feet
32. Purple and mottled clays, 10 feet, with 15 feet of yellow, micaceous sands below 25 feet
33. Purple and mottled clays, 10 feet, with 10 feet light yellow, coarse, cross-bedded pebbly (chert) sands 20 feet
34. Purple and mottled clays 10 feet
35. Purple and mottled clays 10 feet
36. Dark gray, laminated clays, sandy partings, 25 feet, and gray sand indurated, 15 feet, at Venable's and near Saunders' Ferry 40 feet
37. Sandy clays, with leaf impressions, black scales like graphite fragments of lignitized stems.

Figure 27, Column 2, *Alabama River*.

1. Vicksburg. White Limestone, with *Orbitoides mantelli;* hill back of Claiborne, also back from river, from Marshall's Landing to Gainestown At least 140 feet
2. Jackson. Argillaceous White Limestone, with bones of *Zeuglodon cetoides*, phosphatic nodules, and marls, from Claiborne to Marshall's Landing 60 feet

3.	Scutella bed, followed by coarse, ferruginous sands, of which 17 feet is highly fossiliferous; hard, sandy ledge at base	30 feet
4.	Calcareous clay, alternating with greensand containing *Ostrea sellaeformis*	25 feet
5.	Light gray calcareous sands, traversed by hard, sandy ledges, clayey in part, *Ostrea sellaeformis* characteristic greensand, and shells at base	35 feet
6.	Blue clay, passing into greensand, upper half with fossils, lower half highly fossiliferous	22 feet
7.	Calcareous, clayey sands	9 feet
8.	Coarse ferruginous marl 8 feet followed by 20 feet of light yellow sands, few fossils	23 feet
9.	Bluish, jointed clay	12 feet
10.	Light colored, aluminous sandstones, claystones, and siliceous sandstones	75 feet
11.	Reddish, cross-bedded sands, 2 feet lignite at base	22 feet
12.	Laminated, sandy clays, gray color	15 feet
13.	Yellow sands, passing below into gray, laminated, sandy clay	25 feet
14.	Greensand marl, Bell's Landing	10 feet
15.	Gray, laminated, sandy clays 22 to 23 feet, passing into clay marl, Gregg's Landing, 5 feet	30 feet
16.	Sandy clays of prevailing gray color, varying in degree of sandstone and coarseness of lamination, 1 foot greensand marl at base	50 feet
17.	Gray, sandy clays	10 feet
18.	Gray, sandy clays, alternately thin, laminated, and heavy bedded; indurated by glauconitic clay on top and greensand bed in middle	37 feet
19.	Glauconitic sands, with *Gryphaea thirsae*, indurated ledges passing through beds	18 feet
20.	White cross-bedded sands	12 feet
21.	Bluish, clayey, glauconitic sands, with *Gryphaea thirsae*. several hard ledges	50 feet
22.	Glauconitic, clayey sands of varying degree of hardness, bed of lignite 4 feet (Coal Bluff) at base	35 feet
23.	Gray, sandy clays	10 feet
24.	Gray clay, cross-bedded sands, Burford's Landing	10 feet
25.	Gray, sandy clays, forming river banks from Walnut Bluff to Clifton	35(?) feet
26.	Black, sandy clay marl, micaceous, Matthews's Landing	20 feet
27.	Black clay, Midway	5 feet
28.	Argillaceous White Limestone (*Nautilus Rock*)	10 feet
29.	Crystalline limestone (*Turritella*) back of Bridgeport	
30.	Yellowish, micaceous sand (Ripley fossils) at Bridgeport and hills back of landing	55 feet
31.	Dark bluish gray, sandy, micaceous clays, weathering into yellowish shales, with indurated, sandy, projecting ledges at intervals of 5 to 10 feet throughout whole thickness, exposed at Bridgeport, Tear Up Creek, Canton Landing, and hills back of Prairie Bluff and in Gee's Bend	100 feet
32.	Bluish, argillaceous limestone, with phosphatized shell casts, etc., Ripley formation	30-35 feet
33.	Sands of various colors, dark blue, gray to white, traversed by indurated bands of calcareous sands with Cretaceous shells	60 feet
34.	Highly argillaceous limestone, with ledges holding many shells, *Ostrea*, *Gryphaea*, *Exogyra*	1,000 feet

35. Hard, calcareous sands, with fossils strongly phosphatic in part .... 20 feet
36. Alternating layers of horizontally laminated and cross-bedded, yellowish (glauconitic) sands .... 40 feet
37. Laminated blue clays .... 10 feet
38. Blue, micaceous sands .... 15 feet
39. Light colored micaceous sand .... 20 feet
40. Laminated clays and blue sands, thickness not determined.

Figure 27, Column 3, *Chattahoochee River.*

Lower Cretaceous:

1. Light green, highly micaceous sand, resembling weathered schist; but for occasional water-worn quartz pebbles might be taken for schist .... 3 feet
2. Hard clay stained by ferruginous matter; breaks with conchoidal fracture .... 1 foot
3. Hard, white, coarse-grained sand, held together by white clay .... 15 feet
4. Red and gray variegated sandy clay (typical Tuscaloosa); Shown at water's edge, mouth of Bull Creek, Georgia .... 6 feet
5. Strongly cross-bedded coarse sand and pebbles with some few fragments of schist and just enough white clays to hold the mass together. The quartzose pebbles are all well water-worn, while the softer bits of schist are but a slightly abraded. The stratum varies in color from white to lemon yellow and in places green, while the upper becomes mottled purple and yellow. This last phase is most strongly developed at Thomas's bluff, Georgia, due east of Fort Mitchell, Alabama. Top of the Tuscaloosa .... 40 feet

Upper Cretaceous—Eutaw Formation:

6. Dark gray calcareous sand, pyritous and containing nodular masses 6 to 12 inches in diameter with calcite nuclei. These nodules are arranged in strata about 2 feet apart and terminate in an indurated stratum about 12 inches thick. Small fragments of lignite are scattered about through this stratum, and one or two large masses filled with calcified teredos were found. The only other fossils seen were an *Anomia* and an *Exogyra,* probably the young of E. *costata* (?), Say. The fossils are all poorly preserved. Dip at this point, 40 feet to the mile southward .... 15 feet
7. Gray sands of the same nature as the preceding, only to nodules were seen, and the shells increase in quantity, particularly in the lower part. The upper part of the stratum becomes argillaceous and contains many fossil casts, mainly lamellibranchs, causes landslides in the banks like the Black Bluff clays, which they resemble somewhat physically. These sandy clays give rise to Uchee shoals .... 100 feet
8. Laminated dark gray clays, with masses of yellow sand distributed at irregular intervals throughout the stratum; best developed just above Uchee Creek, Alabama .... 25 feet
9. Yellow and white sands, with thin seams of lignitic sand and an occasional "bunch" of gray laminated clay. These sands are exposed in a bluff about 100 yards from the river, just south of Rooney's Mill Creek, Georgia .... 50 feet

10. Quartzose conglomerate much like that at Havana, Hale County, Alabama; forms the shoal at Beden's rock and the bluff at Hatcher's lower landing; merges gradually into a yellow sand .... 50 feet
11. Yellow sand and gray clay, containing bits of leaves. This stratum and the following are seen at Chimney Bluff, Alabama .... 60 feet
12. Light yellow and white sands, containing beds of well-rounded quartzose pebbles, sometimes 20 feet thick. Lignitized logs can be seen protruding from the bluffs. The sands contain a small Exogyra at rare intervals. The supposed top of the Eutaw group .... 45 feet
13. Gray, sandy calcareous clay, with lines of bowlder-like concretions projecting from the bank; first seen at Lawson's wood yard, Georgia. Few fossils occur in the lower part of this stratum. *Exogyra costata*, Say, a mile above Blufftown, Georgia, where characteristic Ripley shells, mainly bivalves, are found in a much decomposed state throughout a stratum 6 to 8 feet thick. The uppermost 10 feet of the stratum is very fossiliferous. The river washes out little cave-like recesses in the banks. Near Jernigan's Landing, Alabama, slight rolls in the strata are seen involving about 20 feet of the sands, and these miniature anticlinals and synclinals continue to within two miles of Florence, Georgia. The dip, estimated from the line of bowlders, averages about 20 feet to the mile and is normal in direction .... 120 feet
14. Two miles above Florence, Georgia, and making part of a bluff 50 feet high at that place, there is a gray sand interlaminated with thin seams of a more argillaceous sand, all of which is unfossiliferous. Dip here about 40 feet to the mile .... 26 feet
15. Gray calcareous sands, containing a small fragile Anomia and a line of hard, round concretionary bowlders .... 40 feet
16. Gray and yellow sands, resembling in physical character those of the Tertiary at Lower Peach Tree, Alabama .... 30 feet

Ripley Formation:

17. Gray, highly fossiliferous marl. The fossils are nearly, if not quite, all bivalves, and are mostly comminuted as if they formed an ancient shore-line. There are numerous shark teeth and a hard black substance resembling in sections the under shell of a turtle, black coprolitic (?) pebbles, and fragments of lignite .... 3 feet
18. Sandy stratum, indurated and containing Ostrea, sp. .... 1 foot
19. Cross-bedded gray sands and clay .... 15 feet
20. Fossiliferous marl, about the same in general character as 17, only little or no lignite was seen, the marl appearing to be somewhat glauconitic. (The strata from 17 to 21, inclusive, form a bluff on the eastern bank five miles below Florence, Georgia .... 2 feet
21. Gray, glauconitic, and calcareous sand, weathering into fucoidal masses and containing a few soft white phosphatic nodules .... 10 feet
22. Gray, fossiliferous marl, shells much decomposed. An occasional lignitized log and numerous slightly phosphatic nodular masses containing fossils occur in this stratum 5 feet
23. About the same in general character as 21, but contains indurated ledges about a foot thick, which show the dip

to average 40 feet to the mile, with numerous rolls; ends just above the mouth of Cowikee Creek, Alabama......170 feet

24. Soft, less coherent sand, gray in color; appears at the mouth of Cowikee Creek, Alabama, from which the southern bank of the creek, composed of this stratum, may be seen to rise 50 feet from the water......60 feet
25. Gray calcareous sand, with indurated ledges, containing *Exogyra costata*, Say; *Gryphaea vesicularis*, Lam; *Hamulus onyx*, *Plicatula urticosa*, *Anomia*, sp.; forms the shoals at Frances bar and bluff at Eufaula, Alabama......190 feet
26. Light gray and yellow sands, interlaminated with sand darker in color, more argillaceous, and containing bits of lignitized leaves and twigs; no other fossils seen; crops out in the gullies of Eufaula next below the Orange sand......20 feet
27. Massive gray sand, with a few fragile fossils and bowlders. This sand is only slightly calcareous, and is more or less lignitic; dip here about 100 feet to the mile......40 feet
28. A more calcareous sand, filled with *Exogyra costata*, Say, and many indurated ledges, giving rise to the first bar below Eufaula......70 feet
29. Light yellow cross-bedded sands enclosed between indurated ledges......20 feet
30. Calcareous gray sands, with bowlders......50 feet
31. Yellow sands and indurated ledges filled with casts, *Exogyra costata*, Say, and echinoids set fast in the ledges. The sands are cross-bedded and contain some lignitic streaks...35 feet
32. Gray fossiliferous sand, with bowlders. The sand is massive, and is fossil-bearing only in the lowest 5 feet......40 feet
33. Brown laminated argillaceous sand; disappears at the mouth of Pataula Creek, Georgia...... 5 feet
34. Light yellow sand, interstratified very irregularly with a gray micaceous sand filled with friable Ripley fossils; mouth of Pataula Creek, Georgia......30 feet
35. Hard sandy ledge; weathered surface jagged; contains *Exogyra costata*, Say, and echinoids; very light yellow in color, white when dry and not weathered......30 feet
36. Gray sand, with indurated ledges; no fossils seen, merges gradually in the upper part into a dark, almost black, sand containing large nodular masses and interstratified with light yellow sands......35 feet
37. White coarse conglomerate, the matrix material being calcareous. The quartzose pebbles decrease in size toward the top, and the stratum becomes more argillaceous. There are many casts, but all too obscure for identification......18 feet
38. Massive blue clay; contains a few bits of teredo-eaten lignite (probably top of Cretaceous)...... 6 feet

Tertiary—Midway (Clayton formation):

39. Massive sandstone; coarse-grained and almost a conglomerate......8 feet
40. Light-yellow siliceous sandstone, containing a large *Ostrea* and numerous obscure casts; five miles above Fort Gaines, Georgia......10 feet
41. White calcareous sand, containing a few obscure casts and an *Ostrea*. The sand sometimes becomes irregularly indurated, and is the source of numbers of small lime springs; forms the lowest part of the bluff at Fort

Gaines, Georgia, and in its uppermost 10 feet contains pockets of white sand, enclosed by black clay, the clay resting in "potholes" in the limestone; estimated at........200 feet

Wilcox Group—Nanafalia Formation:

42. Glauconitic sand filled with *Gryphaea thirsae*, Gabb; *Venericardia planicosta*, and *Crassatella tumidula*..................8-12 feet
43. Gray, calcareous sandy clay, containing bowlders of clay and a few decomposed shells of *Gryphaea thirsae*..............15 feet
44. White and lignitic cross-bedded sands, and sandy gray clay containing one or two ledges of "pseudo-buhrstones" ....50 feet
45. Dark gray argillaceous sand, with few fossils and fragments of water-worn clay balls. The lower part becomes more fossiliferous, containing *Osteodes caulifera*, *Venericardia planicosta* and *Gryphaea thirsae*, etc.................. 6 feet
46. Greenish-gray, fine-grained calcareous sand; very firm, and holding decomposed shells, mainly bivalves.................. 6 feet
47. Coarse glauconitic sands filled with very large shells of *Ostrea compressirostra*, *Venericardia planicosta*, and a small *pecten* resembling the species occurring at Yellow Bluff, on the Alabama.................................... 3 feet
48. Cross-bedded yellow sands, the bedding planes being marked by streaks of gray clay..................................10 feet
49. Yellow and gray sandy clays, containing occasional beds of *Ostrea compressirostra* and *Gryphaea thirsae*. The indurated ledges (seldom over two feet thick) which sometimes occur are of the nature of "pseudo-buhrstone," and are filled with bivalves, the only exception noted being *Turritella mortoni* (large). This member disappears below the surface at the mouth of the first large creek flowing from the Georgia side below Fort Gaines.....75 feet

Tuscahoma Formation:

50. Light yellow and gray sandy clays, containing in the sandier portion bowlders much like those seen at Bell's Landing; no fossils seen. These are undoubtedly the Lower Peach Tree clays and sands. They become more sandy on ascending ....170 feet

Bashi Formation:

51. Light greenish yellow sand filled with bits of decomposed shells and large specimens of *Ostrea compressirostra* and *Venericardia planicosta*. (Interval of 50 yards).................. 3 feet
52. Gray sand filled with decomposed fossils. An irregular indurated ledge (non-fossiliferous) occurs in this stratum. This is probably Bashi, though the only fossil that could be determined with any degree of accuracy is the small oyster so common at the typical locality..............................18 feet
53. Blue, slightly sandy clay.. 6 feet
54. Light yellow, siliceous (sandy) limestone filled with casts and containing pockets filled with shells of *Ostrea compressirostra* ....18 feet

Hatchetigbee Formation:

55. Gray lignitic sandy clay (Hatchetigbee)..............................10 feet

Claiborne:

56. Coarse white sand, containing *Ostrea divaricata* and a few other friable shells in the upper part. (The first flexures since leaving Eufaula occur in this stratum............................12 feet

57. Plain buhrstone, rather sandy........40 feet

58. Light, yellowish green sand containing numbers of small shells of *Ostrea sellaeformis*........45 feet

59. Buhrstone........55 feet

60. Greenish-yellow calcareous clay, with a few decomposed fossils and an occasional large shell of *Ostrea sellaeformis*........12 feet

61. White sandy limestone, with small shells of *Ostrea sellaeformis* in abundance and pockets of larger sized shells. Makes capping ledge to island at mouth of Omussee Creek, where the bluff is about 20 feet high. This stratum is made up of alternate beds of hard and soft strata, all containing more or less abundant remains of *Ostrea sellaeformis*. The harder strata weather out into root-like shapes, and are sometimes rather argillaceous. Many return dips occur in this stratum, stringing it along the banks for many miles further than it would extend normally. The dips are all steep both ways, and many gaps in the succession are caused by the washing out of their softer strata. Owing to these gaps and return dips, it is rather difficult to estimate the thickness of this stratum with much accuracy. It dips below the surface of the river two miles below Gordon, Alabama, and is last seen on the Georgia bank. At Gordon there is a very pronounced return dip. Estimated at (and not exceeding)........60 feet

Jackson Formation:

62. The "Scutella bed;" weathers so as to make it impossible to "count up" its thickness. It is literally full of fossils, mainly *Scutella lyelli*(?) and *Pecten nuperus*, with a few smaller and thicker shells of *Scutella*. A bluff about 20 feet high occurs opposite the mouth of Cowhatchee Creek, Georgia........25-30 feet

Oligocene—Vicksburg Formation:

63. White orbitoidal limestone, seen first at Dougherty's woodyard (Georgia), on the Alabama bank, 9 miles by river from Neal's Landing, Alabama. The limestone contains numbers of echinoids about five miles above Neal's. The limestone continues as far as Miriam's landing, at which place the thickness is........200 feet

Chattahoochee and Alum Bluff:

64. Argillaceous and sandy limestone, alternating with strata of purer character. Contains a *Pecten* and an *Ostrea* very close to our recent *virginica*. This may be termed the Chattahoochee limestone. It is well developed there and in the eastern river bank for the succeeding 10 miles..25 feet

65. Light yellow sand, containing pockets of fossils. Where there are no shells the sand is very calcareous. Fossils resemble those described by Conrad as Miocene from York County, Virginia, and Maryland........35 feet

66. Gray sand, slightly calcareous........5 feet

67. Gray calcareous sand filled with shells. The leading fossil is a Mactra........10-15 feet

68. Black lignitic sand. This contains pyrite, and from the efflorescence of ferrous sulphate arises the name Alum Bluff; varies with preceding........15-15 feet

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GEOLOGICAL SURVEY OF ALABAMA

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BULLETIN NO. 21

STATISTICS OF THE MINERAL PRODUCTION OF ALABAMA FOR 1918

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BY

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[illegible]

NOV 21 1921

GEOLOGICAL SURVEY OF ALABAMA

EUGENE ALLEN SMITH, *State Geologist*

BULLETIN NO. 23

STATISTICS OF THE MINERAL PRODUCTION OF ALABAMA FOR 1918

COMPILED FROM THE MINERAL RESOURCES OF THE UNITED STATES

By

J. H. WINGARD

UNIVERSITY, ALABAMA
1921

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LETTER OF TRANSMITTAL

UNIVERSITY, ALA., FEBRUARY, 1920.

HON. THOMAS E. KILBY,
Governor of Alabama,
Montgomery, Ala.

SIR:—I have the honor to transmit herewith the manuscript of a Report on the Mineral Production of Alabama for the year 1918 with the request that it be printed as Bulletin No. 23 of the Geological Survey of Alabama.

Very respectfully,
EUGENE A. SMITH,
State Geologist.

GEOLOGICAL CORPS.

Eugene Allen Smith, Ph. D.	**State Geologist**
William F. Prouty, Ph. D.	**Chief Assistant**
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Herbert H. Smith	**Curator of Museum**
Roland M. Harper, Ph. D.	**Botanist**
A. T. Donoho	**Secretary**
George N. Brewer	**Field Assistant**

RIVER GAGE HEIGHT OBSERVERS.

Conecuh River at Beck, Ala.

A. W. Lambert	**Route F, Andalusia, Ala.**
C. E. Raley	**Route C. Andalusia, Ala.**

Coosa River at Riverside, Ala.

J. E. Whitehead	**Riverside, Ala.**

Tallapoosa River at Sturdevant, Ala.

A. L. Stowe	**Alexander City, Ala.**

Big Bear River near Red Bay, Ala.

Ed Bullen	**Red Bay, Ala.**

Observations are made every day by these observers of the gage readings at the several stations. From these records when extended through sufficient time, the calculation of available horse power to be obtained from the different streams is made.

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PREFACE

THE statistics of all the miners included in the following pages have been collected in co-operation with the United States Geological Survey, and have been compiled from advance chapters of the *Mineral Resources of the United States,* a publication of the Federal Survey.

The introductory and general matter in each of these articles has either been taken without change from the U. S. advance chapters or has been rearranged or condensed from these chapters, or entirely rewritten to suit it to our present purposes. In each case credit is given to the author.

INTRODUCTION

EUGENE ALLEN SMITH.

AN INSPECTION of the subjoined tables will show that in 1918 there has been a decrease in quantity, and an increase in the value of most of the mineral products of the state.

Following the plan set out by Mr. E. W. Parker in 1913, and continued by the Alabama Survey, we pass in review the production in 1917, and 1918 of Alabama minerals, and the immediate derived products taking them up somewhat in the order of their commercial importance.

Coal.—The Alabama production of coal in 1918 was 19,184,962 short tons valued at $54,752,329, a decrease of 44 per cent in quantity and an increase in value of 20 per cent as compared with 1917. As in 1916 and 1917 the value of coal products in Alabama was more than three fifths of the total mineral output of the state.

Coke.—The coke production of Alabama decreased from 4,892,589 short tons, valued at $28,394,272 in 1917 to 4,352,172 short tons valued at $30,813,378 in 1918. A decrease in quantity of 440,407 short tons and an increase in value of $2,419,106 or 8.5 per cent.

Iron Ore.—In 1918 there was a decrease of 18.2 per cent in the total quantity of iron ore produced in the state, as compared with 1917. 16.2 per cent in the quantity of hematite, and 29.4 per cent in the quantity of brown ore. Despite the large decrease in the quantity of ore produced there was an increase in the value in 1918 of $2,285,026 or 17.5 per cent.

Pig Iron.—The quantity of pig iron marketed in Alabama in 1918 was 2,645,179 gross tons, a decrease of 326,447 tons or 11 per cent and in value $80,893,678, an increase of $16,583,973 or 25.8 per cent. The value of the iron ore and not the value of the pig iron is used in making up the total value of the mineral products of the state.

The total value of the mineral production of Alabama, excluding the value of pig iron and coke, and including the value of the iron ores was in 1918, $77,719,831, compared with $65,423,224 in 1917 of which as already stated more than three fifths is represented by the products of the coal mines, and about one sixth was contributed by the iron mines. The increase in 1918 from 1917 was $31,299,746 or 19.8 per cent.

The principal coal producing counties are Jefferson, Walker, Bibb, Tuscaloosa, and St. Clair, in the order named. The principal iron ore counties are Jefferson, Tuscaloosa, Franklin and Etowah. The combined value of the pig iron and coke made in Alabama in 1918 was $111,707,065. These values are not included in the total as they are represented in the value of the iron ore and coal produced.

Clay Working Industries.—These industries yielded products in 1918 valued at $2,159,104 as compared with $2,106,516 in 1917, an increase of $52,588 or 2.4 per cent. This does not include the value of raw clay sold which in 1918 amounted to $49,193. This was a decrease in quantity of 8,619 short tons or 14.7 per cent, and in value of $35,570 or 41.9 per cent as compared with 1917.

The center of the clay working industry is in Jefferson county, and Birmingham furnished the principal market. Vitrified, common, and fire brick represent a value of $1,678,767 or 77.5 per cent of the total value. In 1918 brick was manufactured in 29 counties by one or more firms.

The pottery products in 1918 consisted of stone ware, yellow and Rockingham ware, and red earthenware, including turpentine cups, and represented a value of $15,324, a decrease of $3,407 or 18.6 per cent as compared with 1917.

Stone.—The quarry products in 1918 showed a slight increase in value over 1917. The value in 1918 was $1,669,721 as compared with $1,611,499 in 1917, an increase of $58,224 or 3.6 per cent.

More than 80 per cent of the total value of the stone produced in 1918 was limestone. Its most important uses are for furnace flux, riprap, and for building purposes. The production of marble decreased about ten per cent in 1918. The figures of the production cannot be given because of the limited number of producers.

Marble holds second place in the value of the quarry products. Beautiful white marble occurring in Coosa and Talladega Counties, is extensively used for building work, (both inside and outside). A black marble which gives promise of future development, has been prospected near Anniston and near Piedmont.

The reader is referred to the body of this bulletin, under Stone, for further details concerning especially the building stone and marble industries.

Cement.—The cement produced in Alabama in 1918 amounted to 1,132,963 barrels valued at $1,719,519 as against 1,329,833 barrels valued at $1,494,879 in 1917. This was a decrease in quantity of 14.8 per cent and an increase in value of 15.05 per cent.

Lime.—The production of lime is not included in that of limestone. In 1918 it amounted to 49,209 short tons, a decrease from the 1917 production of 7,535 short tons or 26.2 per cent. This product was valued at $439,366, an increase over 1917 of $126,835 or 33.1 per cent.

Graphite.—The graphite produced in Alabama is of the crystalline variety, and the value of the product in 1918 was $999,152 as compared with $719,575 in 1917, an increase of 39 per cent in value. There was an increase in quantity produced of 25 per cent.

The Alabama product in 1918 was 68.6 per cent of the total value of the crystalline variety of the United States production as compared with 65 per cent in 1917. The installing of modern machinery and the opening of new plants makes probable that the Alabama product will continue in the coming years to represent a large per cent of the United States production.

Minor Products.—There are produced in Alabama small quantities of the following, barytes, bauxite, millstones, mineral water, sand and gravel, quartz, pyrite, manganese, natural gas, and Fullers earth.

In the following table there is a comparison of the mineral output in Alabama in the years 1917 and 1918. As stated above, the total does not include the value of the pig iron or that of the coke, but it does include the value of the coal made into coke, and of the iron ore sold or used in making pig iron.

Mineral production of Alabama in 1917 and 1918.

PRODUCT	1917				1918			
	Raw.		Derived.		Raw.		Derived.	
	Quantity.	Value.	Quant'y.	Value.	Quantity	Value.	Quantity.	Value.
Coal, short tons	20,068,074	$45,616,992	—	—	19,184,962	$54,752,829	—	—
Coke, short tons	—	—	4,892,589	$28,394,212	—	—	4,352,172	$30,813,378
Iron ore, long tons	7,101,586	18,049,535	—	—	6,121,087	15,384,561	—	—
Pig iron, long tons	—	—	2,971,626	64,309,714	—	—	2,645,179	80,898,687
Limestone, exclusive of marble	—	1,278,908	—	—	—	1,370,667	—	—
Cement, barrels	—	—	1,329,838	1,494,879	—	—	1,132,963	1,719,519
Lime, short tons	—	—	66,744	383,211	—	—	49,209	439,366
Marble	—	—	—	*	—	—	—	*
Clay products	—	—	—	2,106,516	—	—	—	2,159,104
Graphite, pounds	6,223,095	719,575	—	—	7,795,475	999,152	—	—
Sand and gravel, short tons	476,678	222,011	—	—	712,787	406,938	—	—
Clay, short tons	58,667	84,763	—	—	50,048	49,193	—	—
Pyrite, long tons	*	*	—	—	*	*	—	—
Bauxite, long tons	8,281	52,317	—	—	*	*	—	—
Sandstone, including ganister	—	17,098	—	—	—	14,484	—	—
Barytes, long tons	1,976	8,858	—	—	1,794	9,976	—	—
Mineral waters, gallons sold	56,270	5,509	—	—	6,815	1,808	—	—
Gold, fine ounces, Troy	—	—	—	—	37	700	—	—
Mica, sheet, pounds	—	—	—	—	11,800	3,150	—	—
Mica, scrap, short tons	—	—	—	—	—	—	—	—
Manganese ore, long tons	—	—	—	—	*	*	—	—
Natural gas	—	—	—	—	*	*	—	—
Miscellaneous	—	383,052	—	—	—	558,889	—	—
Total†		$65,428,224				$77,719,881		

*Included in Miscellaneous. †Includes raw and derived, except coke and pig iron.

STATISTICS OF THE MINERAL PRODUCTION OF ALABAMA FOR 1918

ABRASIVES.

EUGENE A. SMITH.

ALABAMA'S production of abrasives is at present limited to a small number of millstones (chasers*) of Pennsylvanian age, quarried and made at Dutton, Jackson County; there are, however, several materials in different parts of the State which are sufficiently promising to be worth investigating and thorough testing; the nature and locality of these deposits were treated in Bulletin No. 13, which see. There was no production in 1918.

BARYTES.

(Condensed from Mineral Resources of the United States.)

GEO. W. STOSE.

There was little activity in the barytes industry in 1918, only 1,794 short tons being marketed. This was about 200 tons less than was sold in 1917. The ore came chiefly from two mines in Calhoun County and a mine near Centerville, Bibb County, though several hundred tons were produced near Wilsonville, Shelby County, and Leeds, Jefferson County,

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*Chasers are larger than the regular millstones. They are used for heavier work, such as grinding quartz, feldspar, barytes, etc., and they run on edge. Though they are made with a diameter as short as 24 inches, they are usually turned out with diameters ranging from 50 to 84 inches, and are as much as 22 inches in thickness. These chasers are run on pans paved with roughly cubical blocks of the conglomerate, with edges about a foot in length. In grinding quartz in such pans the chasers are used in the preliminary crushing; then rough blocks, usually three in number, are either attached to or carried along by lateral arms, which in turn are joined to a vertical revolving shaft. By the circular movement of these blocks the material placed in the pan is ground to powder.

The deposits near Jacksonville, Calhoun County; Vincent, Harper, and Wilsonville, Shelby County; and Leeds, Jefferson County, were under development, and a considerable production was made from the mine in Jefferson County, at which a steam-driven hoisting plant and log washer is operated. The mine is about 5 miles south of Leeds in the flat valley bottom of Little Cahaba River. The Chickamauga (Pelham) limestones (Ordovician), in which the valley is cut,* strike north-northeast and dip southeast at steep angles. The mining has exposed the very rough surface of the underlying blue-gray limestone, in which barite in irregular masses replaces the lime and magnesium carbonates. The barytes is mined from the red residual clay overlying the limestone and some large masses of barytes have been found, though the great bulk of the barytes ranges from 1 to 4 inches in size and is of high grade.

From 1 to 3 miles north of Angle station and about 12 miles northwest of Jacksonville, Calhoun County, there are a series of barytes deposits on which a little development has been done. These deposits lie at the base of white quartzite ridge in red residual clay that is derived from blue-gray magnesian limestone, whose age has not been definitely determined but which is probably Knox dolomite.

In the vicinity of Vincent, Harpersville, and Wilsonville, eastern Shelby County, there are small irregular masses of barytes in the red residual clays derived from limestone of Beekmantown age.† Shipments have been made from several small pockets, and it is reported that at a number of places indications point to larger bodies.

Details concerning the manufacture of ground barytes, of lithopone, and of barium chemicals and their uses are given in Bulletin No. 19 of the Alabama Geological Survey, and in the Mineral Resources of the United States for 1916. E. A. S.

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*Butts, Charles, U. S. Geol. Survey Geol. Atlas, Birmingham folio (No. 175), 1910.

†Butts, Charles, U. S. Geol. Survey Geol. Atlas, Montevallo Columbiana folio (in preparation).

Crude barytes produced and marketed in the United States, by States, 1916-1918.

STATE.	1916			1917			1918		
	Quantity (short tons).	Value.	Average price per ton.	Quantity (short tons).	Value.	Average price per ton.	Quantity (short tons).	Value.	Average price per ton.
Alabama	7,631	$27,198	$3.56	1,976	$8,868	$4.49	1,794	$9,976	$5.56
Colorado	481	3,005	6.25	——	——	——	——	——	——
Georgia	104,734	401,295	3.83	111,300	601,895	5.41	69,318	418,178	6.03
Kentucky	11,068	54,995	4.97	6,720	36,084	5.37	*	*	——
Missouri	58,223	365,111	6.27	59,046	391,363	6.63	49,094	393,738	8.02
North Carolina	878	3,246	3.70	1,019	5,080	4.99	*	*	——
Tennessee	32,416	123,986	3.85	16,972	79,058	4.66	22,542	141,844	6.29
Other states†	6,471	32,396	5.01	9,855	48,836	4.96	12,620	81,169	6.43
	221,952	1,011,232	4.56	206,888	1,171,184	5.66	155,368	1,044,905	6.73

*Included in "Other states."

†Includes, 1916 and 1917: California, Nevada, South Carolina, and Virginia; 1918: Kentucky, Nevada, New Mexico, North Carolina, South Carolina, Virginia, and Wisconsin.

BARYTES PRODUCERS IN 1918.

C. T. Weldon, Centerville, Bibb County, Alabama; Saginaw, Shelby County, Alabama; Longview, Shelby County, Alabama; Wilsonville, Shelby County, Alabama.

Glidden Barytes Co., 509 1st Nat'l Bank Bldg., Birmingham, Ala. Mines at Jacksonville (Angel), Calhoun County.

Groves & Watts (Angel Mining Co.), Rome, Ga. Mine at Jacksonville (Angel), Calhoun County.

BAUXITE AND ALUMINUM.

By James M. Hill.

Bauxite.

DOMESTIC PRODUCTION.

THE quantity of bauxite marketed in the United States in 1918 was 605,721 long tons, which had a value at the mines of $3,447,992 an increase over the production of 1917 of about 7 per cent in quantity and about 11 per cent in value. The production from the Georgia, Alabama, and Tennessee fields in 1918 was 42,829 long tons, a decrease of 31 per cent, but the Arkansas production of 562,892 long tons showed an increase of approximately 11 per cent.

Of the quantity of domestic bauxite marketed in 1918, apparently the producers of aluminum took about 419,043 long tons, the makers of chemicals about 63,896 tons, makers of abrasives about 112,908 tons, and the makers of refractories about 9,874 tons. As will be noted, the total quantity of domestic bauxite marketed is 16,058 tons greater than the apparent domestic consumption given in the table below. It is believed that this discrepancy is in part due to stocks carried at consuming works, and in part to loss in the manufacture of "refined bauxite," the product that is largely exported.

As will be seen by the table, the domestic consumption of bauxite in 1918 increased about 6 per cent over the consumption in 1917, and the domestic deposits supplied nearly the whole demand. The larger part of the exports were apparently made to Canadian aluminum and abrasive makers.

Bauxite produced and consumed in the United States, 1914-1918.

YEAR.	DOMESTIC PRODUCTION					
	Georgia, Alabama, and Tennessee		Arkansas.		Total •	
	Quantity (long tons)	Value.	Quantity (long tons)	Value.	Quantity (long tons)	Value.
1914	24,071	$92,508	195,247	$976,686	219,318	$1,069,194
1915	28,245	144,345	268,796	1,370,489	297,041	1,514,834
1916	49,190	284,810	375,910	2,011,590	425,100	2,296,400
1917	62,134	395,051	506,556	2,724,007	568,690	3,119,058
1918	42,829	314,112	·562,892	3,133,880	605,721	3,447,992

Bauxite produced and consumed in the United States, 1914-1918—Continued.

YEAR	Imports		Exports*		Domestic consumption	
	Quantity (long tons)	Value	Quantity (long tons)	Value	Quantity (long tons)	Value
1914	24,844	$96,500	†5,374	†$240,084	238,788	$925,610
1915	3,420	17,107	16,082	717,186	284,379	814,755
1916	80	87	17,989	987,454	407,191	1,309,033
1917	7,691	28,989	21,791	1,323,926	554,590	1,824,121
1918	3,653	14,791	19,711	1,523,688	589,663	1,939,095

*Includes bauxite concentrates.

†Figures cover six months, July to December, 1914. Not separately classified by Bureau of Foreign and Domestic Commerce prior to July, 1914.

The first bauxite produced in the United States was that obtained in 1889 from deposits in the north Georgia field. In 1891 the Alabama deposits made their first production, and practically all the bauxite mined in the United States until 1899 came from these two States. The Arkansas deposits made their first output in 1896, but it was not until 1900 that their influence was felt. In 1907 the Tennessee deposits first began shipping. The following table gives a historical record of the remarkable growth of the bauxite industry in the United States, which has been particularly rapid in the last 10 years.

MARKET AND PRICES.

The market for bauxite in the United States is east of Mississippi River, and the largest consumers are located at or near the cities of East St. Louis and Aurora, Ill.; Detroit, Mich.; Cincinnati, Ohio; Knoxville, Tenn.; Philadelphia and Erie, Pa.; Niagara Falls and New York City, N. Y.; and Boston, Mass. Recently a number of municipal and industrial waterworks have installed small plants for the manufacture of aluminum sulphate for local use in purification of water. A complete list of those known to the United States Geological Survey to be users of bauxite follows:

USERS OF BAUXITE.

Aluminum Co. of America, Pittsburgh, Pa.
Booth Chemical Co., P. O. Box 203, Elizabeth, N. J.
Carborundum Co., Niagara Falls, N. Y.
Charles Lennig & Co. (Inc.), 112 South Front Street, Philadelphia, Pa.
Charles Taylor Sons Co., Cincinnati, Ohio.
Columbus Waterworks, R. D. 5, Columbus, Ohio.
Cumberland Waterworks, R. D. 3, Cumberland, Md.
Detroit Chemical Works, 238 Junction Avenue, Detroit, Mich.
E. I. du Pont de Nemours Powder Co., Wilmington, Del.
Erie Chemical Works, 31 Union Square W., New York, N. Y.
Exolon Co., 156 Sixth Street, Cambridge, Mass.
General Abrasives Co., Niagara Falls, N. Y.
General Refractories Co., Trinity Building, New York.
Harbison-Walker Refractories Co., Pittsburgh, Pa.
Jerecki Chemical Co., St. Bernard Station, Cincinnati, Ohio.
Laclede-Christy Clay Products Co., St. Louis, Mo.
Masillon Stone & Fire Brick Co., Masillon, Ohio.
Merrimac Chemical Co., 33 Broad Street, Boston, Mass.
Metropolitan Water District of Omaha, Omaha, Nebr. (R. B. Howell, general manager.)
Montclair Waterworks, Little Falls, N. J.
Norton Co., Worcester, Mass. (also Niagara Falls, N. Y.)
Pennsylvania Salt Manufacturing Co., Widener Building, Philadelphia, Pa.
Springfield Waterworks, Springfield, Mass.
Superior Chemical Co., Joliet, Ill.

Bauxite is graded according to its chemical composition and is sold to the consuming industries on the basis of analysis. Apparently low content of silica and titanium is essential to the aluminum industry, but the content of iron may be fairly high, though bauxites low in iron and titanium are preferred by the makers of alum and aluminum sulphate. Makers of abrasives appear to be able to use bauxites of lower grade and containing larger proportions of silica and iron than are permissible in bauxite for other uses, but most abrasives are made from bauxites low in silica and iron. The bauxite used for refractories must apparently be fairly low in iron.

The prices received for bauxite in 1918, as reported by producers, ranged from $5 to $12 a long ton; the average price paid for the whole of the domestic bauxite sold in this country was $5.69 a long ton at the shipping point. It must be realized that the average price computed from the assigned value of the total production is considerably below the price at which bauxite can be purchased in small lots, because of the fact that the larger consumers operate their own mines and assign to the output an arbitrary value, which is presumably based on operating costs.

OCCURRENCE AND CHARACTER OF BAUXITE IN THE UNITED STATES.

The known commercial bauxite deposits of the United States are in Calhoun, Cherokee, and DeKalb counties, Ala.; Pulaski and Saline counties, Ark.; Bartow, Floyd, Meriwether, Sumter, and Wilkinson Counties, Ga.; and Carter and Hamilton counties, Tenn. A brief description of the geology of the domestic deposits was given in the report for 1916,* and detailed descriptions of the deposits in central Georgia have been published by the Georgia Geological Survey.†

The bauxite from all localities in the United States, though it may vary in chemical composition, is on the whole similar in general appearance, with the exception of the "granitic bauxite" of the Arkansas field. The greater part of the American bauxite appears to be made up of rounded pebble-like bodies set in a fine-grained matrix, which may also consist of small rounded particles or may be as fine grained as the finest clay. The pebble or pisolite form is so general that it is the conspicuous characteristic of American bauxite.

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*Hill, J. M., Bauxite and aluminum in 1916: U. S. Geol. Survey Mineral Resources, 1916, pt. 1, pp. 161-165, 1917.

†Shearer, H. K., A report on the bauxite and fuller's earth of the Coastal Plain of Georgia: Georgia Geol. Survey Bull. 31, 1917.

There is only one way to determine the value of bauxite, and that is by chemical analysis, which should show total silica, alumina, titanium oxide, iron oxide, and water. Bauxite of commercial grade should carry at least 52 per cent of alumina.

A few characteristics that indicate in a general way the quality of bauxite may be mentioned, though none of them are to be depended on. In general, bauxite of fair grade will not show the marks of a hammer when it is hit a glancing blow, though some bauxite has been shipped which can be cut with the hammer. Good bauxite that has been dried either in the open or in kilns when thrown on a hard floor has a distinct rattle, which bauxitic clay does not have. The pisolites of a lighter-colored bauxites of the central Georgia field have a peculiar brownish-buff color and look something like horn or flint; they ordinarily can not be broken or marked with the finger nail in bauxites of good grade.

Some measure of the relative quality of dried bauxite can be had by grinding a sample in an agate mortar for half a minute. A bauxite of good grade will be found hard to grind and will stick to the mortar with such tenacity that it will have to be scoured out; a poor bauxite or bauxitic clay will grind much more easily and will stick very little, if at all; and clay or kaolin grinds with ease and does not stick to the mortar. Similar results are found if the sample is rubbed on glass; the glass will not be scratched by even high-grade bauxite.

NOTES ON THE BAUXITE MINES, BY STATES.

Alabama.

During 1918 three companies were operating in the Alabama field—the Republic Mining & Manufacturing Co., near Rock Run, Cherokee County; the Consolidated Mining Co., near Fort Payne, Dekalb County; and the

Expert Prospecting & Development Co., near Talladega, Talladega County.

The production of bauxite from Alabama in 1918 showed a decrease of about 40 per cent from the production in 1917. The output was used for the manufacture of alumina chemicals to the extent of 79 per cent; abrasives, 17 per cent; and refractories, 4 per cent.

Arkansas.

The American Bauxite Co., Globe Bauxite Co., E. I. du Pont de Nemours Co., Republic Mining & Manufacturing Co., and the Norton Co. mined bauxite from deposits in Saline and Pulaski counties, Ark. The largest production was made from the deposits near Bauxite, Saline County.

The bauxite mined from the Arkansas deposits is of high grade, as is shown by the fact that more than 75 per cent of the output in 1918 was used for the manufacture of aluminum, nearly 18 per cent for abrasives, 5 per cent for chemicals, and 2 per cent for refractories.

Georgia.

The total production of bauxite from Georgia in 1918 was approximately 36,500 tons, a decrease of about 30 per cent from the production in 1917. Wilkinson County produced the largest quantity, Floyd county was second, Sumter County third, Bartow County fourth, Randolph county fifth, and Meriwether county sixth in rank of output. The mines near Cuthbert, Randolph County, were operated for the first time in 1918.

Georgia bauxite appears to be more suitable for the manufacture of alumina chemicals than for other purposes. The consumption of the output in 1918 was distributed as follows: Eighty-two per cent for alumina chemicals and 18 per cent for abrasives.

New Mexico.

The impression seems to have prevailed that the alunogen deposits in Grant county, N. Mex., are bauxite.

These deposits were first described by Blake and also in more detail in a privately printed pamphlet. They were described in considerable detail by Hayes, who found that the deposit was a very highly altered volcanic breccia outcropping in a more or less circular area surrounded by basalt. He states that this breccia probably represents a core of an andesitic volcano which broke through the basalt flow of the surrounding region and that the alteration of the brecciated andesite was probably due to the escape of volcanic gases which followed the intrusion. The altered breccia Hayes shows by analyses to be "essentially the silicate of alumina," and not bauxite. There are large quantities of alumina sulphate and iron-alumina sulphate which form as incrustations from 2 to 4 feet thick on the surface, and probably considerable soluble sulphate in the porous altered breccia. At present, however, there seems to be little possibility of utilization of this material on account of its inaccessibility.

Tennessee.

The bauxite deposits on Missionary Ridge were reported idle during 1918. A small output was made at the mines near Elizabethton, Carter County, Tenn.

BAUXITE PRODUCERS IN 1918.

Republic Mining & Mfg. Co., 1111 Harrison Bldg., Philadelphia, Pa. Mine at Rock Run, Cherokee County.

Consolidated Mining Co., Fort Payne, Ala. Mine at Fort Payne, DeKalb County.

Expert Prospecting & Developing Co., Jefferson County Bank Bldg., Birmingham, Alabama. Mine at Talladega, Talladega County, Alabama.

National Bauxite Co., 3500 Gray's Ferry Rd., Philadelphia, Pa.

ALUMINUM.

DOMESTIC PRODUCTION AND CONSUMPTION.

The value of primary aluminum produced in the United States in 1918 was $41,159,225, a decrease of about 10 per cent from the value of the output in 1917. The decrease was due very largely to the decline in price of aluminum during 1918 and does not represent a corresponding decline in quantity of output.

Value of aluminum produced and consumed in the United States, 1913-1918.

YEAR	Domestic production		Imports¶	Exports‖	Apparent consumption
	Primary metal	Secondary metal†			
1913	$9,450,000	$2,199,480	$4,784,302	$966,094	$15,467,688
1914	10,080,000	1,673,140	4,074,583	1,546,510	14,281,213
1915	16,280,000	5,802,100	1,841,779	3,682,117	20,241,762
1916	33,900,000	23,480,200	1,785,870	15,417,134	43,698,936
1917	45,882,000	16,711,800	56,890	14,586,467	48,064,223
1918	41,159,000	10,113,600	554,586	10,869,388	40,957,798

‡Value based on average open market price, as quoted by Eng. and Min. Jour.

¶Imports for consumption, figures from Department of Commerce reports. Includes aluminum in crude form, leaf, sheets, plates, bars, strips, wire, rods, and all manufactures of; table, kitchen, and hospital ware.

‖Exports of aluminum and manufactures of; figures from Department of Commerce reports.

MARKET AND PRICES.

There were practically no open-market dealings in aluminum during 1918, as the industry was essentially under Government regulation. The supply of aluminum was not large and little of the metal was used except for war purposes.

Open-market prices of 37 cents a pound were quoted until March 2, 1918. On March 4 the base price for sales of aluminum was fixed by the Government at 32 cents a pound, but this was raised to 33 cents a pound on June 1, 1918, and remained unchanged till the end of the year. The fixed price was early interpreted to cover secondary aluminum as well as primary. The average price for the year was 33.6 cents a pound. The open-market prices of aluminum for the years 1914 to 1918, inclusive, as given weekly by the Engineering and Mining Journal, are of interest as showing the uncertainty of the market concerning the supply of aluminum to meet peace demands as well as the heavy drafts for war purposes. It is also interesting to note that the Government-fixed base price was in essential accord with the prevailing contract price under which the single producer of aluminum sold most of the output in 1916 and 1917.

There was a slight increase in price at the time of the declaration of war in Europe, followed by a corresponding decline. With the large orders from foreign countries early in 1915 the market advanced rapidly but did not attain its maximum until late in 1916. During 1917, presumably under the unified Allied buying arrangements which did away with so much competitive bidding, the price declined as rapidly as it had risen, and it remained almost stationary at the maximum contract price of the largest producers in 1917 until the Government fixed the price on March 4, 1918.

Prices of aluminum, 1914-1918, in cents per pound.†

YEAR	Average open market price, small lots	Contract price
1914	18.63	*
1915	33.98	20–31
1916	60.71	31–37
1917	51.59	31–37
1918	36.6	32–33

†Eng. and Min. Jour. quotations in annual review numbers.

*No figures published, but it seems reasonable to believe that contracts were made on approximately the same basis as for 1912.

NOTES ON THE ALUMINUM INDUSTRY.

Expansion of the plant capacity of domestic makers of aluminum continues. Though war conditions have interfered with the completion of some projects, at others changes have been made which should result in greater output.

Two very interesting papers have been published within the year on the European practice of making aluminum.

Anonymous, Aluminum (bauxite) deposits and the production of aluminum: Engineering (London), vol. 166, pp. 163-165, 191-193, 218-220, 1918.

Nissen, O., Aluminum manufacturing processes used in Europe (translated from Teknisk Tidskrift, Aug., 1917): Chem. and Met. Engineering, vol. 19, pp. 804-815, December, 1918.

In both these papers notes on the making of alumina and artificial cryolite are given, as well as more or less detailed information on electric-furnace practice. The paper in Engineering gives considerable information relative to the capacity of various aluminum works in Europe and also considerable discussion of the supplies of raw materials available to European makers of aluminum. Nissen's article deals principally with the metallurgy of the metal. He discusses briefly the history of the manufacture of aluminum and the development of electric furnaces for this purpose; he notes also the manufacture of alumina by the Deville-Pechery and Bayer processes, and mentions various modifications of these processes for the treatment of high-silica bauxites. The methods of manufacture of artificial cryolite and carbon electrodes, those absolutely essential materials in the manufacture of aluminum, are also pointed out by Nissen, and he gives notes on the actual smelting of the metal.

A comprehensive work on the use of aluminum in the industries by Escard has recently been published.[1] It is impossible in this report to review the work adequately Some information is given concerning the metallurgy of aluminum, though the book deals primarily with the utilization of aluminum and its alloys.

There can be little question that the aluminum industry of the central European powers has seen considerable change during the war period. In all probability we shall soon learn of the possibility of using very low grade bauxite, or possibly clay, for the manufacture of alumina low enough in silica for the production of high-grade metal. In this connection it is of interest to note that the by-product alumina formed in the separation of potash from alunite is now being marketed. Apparently this material has not yet been found satisfactory for other uses than refractories and abrasives, though patents for its use in the preparation of aluminum have been granted.

The British Aluminum Co., whose plants are at Foyers and Lockleven, had contemplated great expansion during 1918, but their plans do not appear to have materialized, as the House of Lords failed to grant permission for the necessary extensive hydroelectric development in

Scotland. This company controls the aluminum works at Higeland and Strangfiord, Norway.

Alum and aluminum sulphate produced in the United States and aluminum salts imported, 1914-1918.

YEAR	PRODUCTION						IMPORTS*	
	Alum			Aluminum sulphate				
	Quantity (short tons)	Value	Price per ton	Quantity (short tons)	Value	Price per ton	Quantity (short tons)	Value
1914	18,238	565,989	31.03	164,954	2,942,572	17.84	2,891	73,028
1915	24,915	699,256	28.07	169,153	3,224,495	19.06	1,408	34,320
1916	27,257	1,177,881	43.21	153,860	4,410,741	28.67	1,247	68,660
1917	19,714	1,017,083	51.60	178,738	5,746,427	32.15	507	39,088
1918	20,286	1,051,449	51.83	209,079	6,473,086	30.96	231	18,519

*Includes alumina, aluminum hydrate or refined bauxite, alum, alum cake, aluminum sulphate, aluminous cake, and alum in crystals or ground.

BAUXITE ABRASIVES.

Bauxite abrasives sold under various trade names, such as alundum, aloxite, exolon, and lionite, are made by fusing bauxite in an electric furnace. These products are sold in the form of powders, cloth, grinding stones, and wheels of various shapes, and for a multitude of uses. Owing to the objection of one of the large producers, it is not possible to give figures of production of bauxite abrasives for 1918. The marketed production in 1917 was 48,460 short tons, which was made from approximately 109,580 long tons of bauxite. In 1918 approximately 112,908 long tons of bauxite was used for the manufacture of abrasives.

HIGH-ALUMINA REFRACTORIES.

There are two classes of high-alumina refractories now on the market. What are commonly called bauxite brick are made by mixing various proportions of calcined bauxite or high-alumina clay with a bonding material such as fire clay, sodium silicate, or lime. Refractories of this character are being made by the Laclede Christy Clay Products Co., the Harbison-Walker Refractories Co., Charles Taylor & Sons, and the Massillon Stone & Fire Brick Co. Not all the refractories made by these companies are sold as bauxite brick, and, in fact, some do not contain bauxite. The other class of high-alumina refractories consists of those made by the electric fusing of bauxite. These are manufactured by the companies that make artificial abrasives.

The use of high-alumina refractories seems to be expanding, particularly in the construction of copper, iron, and lead furnaces and of cement kilns. No figures are available to show the production of high-alumina refractories, though it is known that at least 2,313 long tons of bauxite was consumed in making refractories in 1917 and, apparently, 9,874 long tons in 1918.

OTHER BAUXITE PRODUCTS.

A little more than 69 per cent of the domestic output of bauxite in 1918 went into aluminum, manufacturers of aluminum salts used about 10 per cent, 19 per cent was consumed in the manufacture of bauxite abrasives, and 2 per cent was used by makers of "high-alumina refractories," also called bauxite brick.

Within the last two years many foreign and domestic patents have been issued relating to the use of bauxite in the fixation of nitrogen, the manufacture of aluminum salts, and the fabrication of abrasives and refractories. Copies of these patents may be obtained from the United States Patent Office, Washington, D. C.

ALUMINUM SALTS.

The principal aluminum salts made in the United States are alumina, alums, usually ammonium and sodium alums, aluminum sulphate, and aluminum chloride. Alumina is largely consumed in the manufacture of aluminum, and no figures of domestic production are available for publication.

Alums of various qualities are produced at 9 plants in the eastern United States, the total production of alum in 1918 being 20,286 short tons, valued at $1,051,449, an increase of approximately 3 per cent in quantity and value over the production in 1917. The average price reported by makers of alums was $51.83 a short ton.

Aluminum sulphate is made at 24 plants, 7 of which are at municipal or industrial waterworks, which consume their entire output. The total quantity of aluminum sulphate produced in the United States in 1918 was 209,079 short tons, of which 7,002 short tons did not enter the market but was used for water purification at the place of manufacture. The quantity of domestic aluminum sulphate which entered the market, 202,077 short tons, was greater than the quantity in 1917 by approximately 16 per cent, and the total domestic production increased about 17 per cent. The price reported by makers of aluminum sulphate for the output in 1918 averaged $30.96 a short ton.

Aluminum chloride is used for various purposes, among which may be mentioned the refining of mineral oils. This salt was produced at three plants in 1918, and the total output reported to the Geological Survey was 4,224 short tons, valued at $338,710, or approximately $80 a short ton.

CEMENT.

EUGENE A. SMITH.

PORTLAND CEMENT.

RESOURCES.

ALABAMA contains large supplies of limestone, chalk, clay and shale well adapted to Portland cement manufacture, and widely distributed throughout the State. Coal and labor are abundant and cheap, transportation facilities are excellent, and many of the best limestone and chalk localities are situated on navigable rivers, giving ready access and cheap water transportation to Galveston, New Orleans, Mobile, Charleston, and other ports of the Gulf and Atlantic Coasts. This advantage of location was immensely increased with the opening of the Panama Canal for cement plants located in Alabama are more than a thousand miles nearer to the Isthmus than their nearest possible competitors.

The limestones and shales of the northern part of the State lie so close to each other, and above all so close to the great coal mines which must supply the fuel, that the establishment of Portland cement plants near the coal mines would give to this industry in Alabama the same advantages which the proximity of the iron ore, the coal, and the stone has given to the iron industry, and which has placed our State beyond competition.

As a Portland cement mixture, ready for burning, consists approximately of 75 per cent lime carbonate and 25 per cent of clayey matter, the material furnishing the lime carbonate is necessarily of more economic importance than that from which the silica and alumina are derived. In consequence, a Portland cement plant is usually located in the immediate vicinity of a suitable limestone, while. the clay or shale required to complete the mixture may be brought some distance.

The limestone formations in North Alabama which can supply the stone adapted for use in cement manufacture are the Trenton or Pelham limestone and the Bangor or Subcarboniferous. In close proximity to both these limestone formations are the shales of the Clinton, Subcarboniferous and Coal Measures.

At the present time there are two cement plants in North Alabama, namely, the Standard Portland Cement Co., located at Leeds in Jefferson County, and the Coosa Portland Cement Co., located at Ragland in St. Clair County. Both of these plants make use of the hard Trenton limestone, and the Standard Cement Co., according to Burchard of the U. S. Geological Survey, uses the shale of the Clinton formation whilst the Ragland Company makes use of the shales of the Coal Measures. Up to the present time no establishment is utilizing the Bangor limestone.

In Middle Alabama the soft, chalky Cretaceous limestone of the Selma Chalk is the material utilized by the Alabama Portland Cement Co., at Spocari, near Demopolis. The same company makes use of residual clays overlying and derived from the weathering of the Selma Chalk. During 1915, and since, there was no production from the Demopolis plant.

In Southern Alabama the St. Stephens limestone outcropping east and west across the State, furnishes excellent material for Portland cement manufacture, using either residual clays from decomposition of the limestone, or the clays of the Grand Gulf formation which are almost everywhere in close proximity to the limestone.

PUZZOLAN CEMENT.

During the past seven years only one establishment in Alabama, the Southern Cement Company, North Birmingham, has been engaged in the manufacture of slag cement, using the material from the furnaces about Birmingham. The production is included in the returns for Portland cement and cannot be given separately.

Owing to the fact that there was in Alabama in 1918 only one producer of puzzolan cement, and not more than two operating plants in the Portland cement industry, it is necessary to combine the productions of the two industries in order to avoid publishing figures which were given to the Survey in confidence. The tabular results of such a combination are, however, necessarily inconsistent and not to be taken too literally, since the weights per barrel of the two kinds of cement vary.

The total quantity of Portland and Puzzolan cement sent to market in 1918, was 1,132,963 barrels, valued at $1,719,519, as compared with 1,329,833 barrels valued at $1,494,879 in 1917; a decrease of 196,870 barrels or 14.8 per cent, and an increase in value of $224,640 or 15.05 per cent.

Quantity and value of Portland and Puzzolan cement, marketed in Alabama in 1917 and 1918.

	No. of Producers	Quantity (Bbls.)	Value
1917	3	1,329,833	1,494,879
1918	3	1,132,963	1,719,519
Increase or decrease		— 196,870	+ 224,640
Per cent of increase or decrease		— 14.8	+ 15.05

RECOVERY OF POTASH FROM PORTLAND CEMENT MATERIALS.

It has been noticed that the flue dust in a cement plant often contains notable percentage of potash, and efforts have been made to utilize this dust in the extraction of potash. Flue dust from the Standard Cement Plant shows 2½ per cent, and above potash, and it is in contemplation to utilize this, and the suggestion is also made to use feldspar in the manufacture. Up to the present time, however, there has been no commercial production of any potash from this source.

CEMENT PRODUCERS IN 1918.

Coosa Portland Cement Co., 607 Stock Exchange Bldg., Philadelphia Pa., or Ragland, Ala. Works at Ragland, St. Clair County, Ala.

Southern Cement Co., Birmingham, Ala. Works at North Birmingham, Jefferson County, Ala.

Standard Portland Cement Co., 9 Prioleau St., Charleston, S. C. Works at Leeds, Jefferson County, Ala.

CLAY AND CLAY PRODUCTS.

CLAY.

JEFFERSON MIDDLETON AND EUGENE A. SMITH.

CLAY available for the manufacture of clay products is one of the most widely distributed of our minerals. Hence there are clay-working plants scattered over every State and Territory in the Union. Miners of the low-grade clays are usually also the manufacturers, but as the higher grades of ware are reached, the rule is that fewer and fewer manufacturers are also miners, until in the highest grades of ware the rule is that the manufacturer buys and does not mine the clay he uses. The figures given in the following tables represent clay that is mined and not manufactured by the miner, but is sold as clay. The clay thus sold is small in quantity compared with the total production and includes mainly clay used for high-grade pottery and tile, for paper making, and for refractory products.

The total amount of clay mined in Alabama and sold as such in 1918, was 50,048 short tons valued at $49,193. This was a decrease in quantity of 8,619 short tons or 14.7 per cent, and of $35,570 or 41.9 per cent in value as compared with 1917.

Below is a table giving the production and value of clay mined and sold in Alabama from 1908 to 1918 inclusive, and a comparison of the production of 1917 and 1918:

Production of clay in Alabama from 1908 to 1917 inclusive, and a comparison of the production in 1917 and 1918.

YEAR	FIRE CLAY		MISCELLANEOUS CLAY		TOTAL	
	Quantity Short Tons	Value.	Quantity Short Tons	Value.	Quantity Short Tons	Value
1908	68,289	$48,988	24,000	$12,000	92,289	$60,988
1909	45,137	35,345	18,271	5,587	63,408	40,932
1910	54,482	32,395	20,600	5,650	75,082	38,045
1911	35,208	29,909	———	———	35,208	29,909
1912	38,552	31,414	4,500	2,000	43,052	33,414
1913	49,901	53,269	*	*	49,901	53,419
1914	27,973	34,607	———	———	27,973	34,607
1915	31,520	34,882	*	*	31,870	35,232
1916	40,235	50,618	1,244	435	41,479	51,053
1917	41,951	67,674	———	———	58,667	84,763
1918	49,516	48,611	532	582	50,048	49,193
Increase or decrease	+ 7,565	— 19,063	———	———	— 8,619	— 35,570
Percentage	+ 18.	— 28.4	———	———	— 14.7	— 41.9

*Not divulged but included in total.

In 1917 the average value of fire clay of Alabama was $1.61 per short ton, and the value of the Alabama product was 1.2 per cent of the total value of the fire clay of the United States. In 1918 the average value of the Alabama fire clay was $0.98 per short ton, and the value of the Alabama product was .82 per cent of the total value of the fire clay produced in the United States.

RAW CLAY PRODUCERS IN 1918.

Bibbville Fire Brick & Mfg. Co., 850 Brown-Marx Bldg., Birmingham, Ala. Works at Bibbville, Bibb County, Ala.

Bessemer Fire Brick Co., 1148 Brown-Marx Bldg., Birmingham, Ala. Works at Bibbville, Bibb County, Ala.

Lehigh Coal Co., 722 Brown-Marx Bldg., Birmingham, Ala. Works at Lehigh, Blount County, Ala.

Southern Refractories Co., Fort Payne, Ala. Works at McFalls, DeKalb County, Ala.

Imperial Coal & Coke Co., Birmingham, Ala. Works at Bradford, Jefferson County, Ala.

Harbison-Walker Refractories Co., 1808 Farmers Bank Bldg., Pittsburgh, Pa. Works at Fairfield, Jefferson County, Ala.

Robertson Brick Co., Ave. B & 6th St., Birmingham, Ala. Works at East Birmingham, Jefferson County, Ala.

Bibby Coal, Shale & Clay Co., Littleton, Ala., Works at Littleton, Jefferson County, Ala.

CLAY PRODUCTS.

The state of Alabama is rich in clays of many kinds, yet its rank as a clay working state is low, being nineteenth in 1917 and eighteenth in 1918. Its clay products in 1918 reported by 49 operators were valued at $2,159,104—brick and tile $2,143,780, pottery $15,324—an increase over 1917 of $105,176 or 2.5 per cent. Alabama ranged fourth in quantity, and value of vitrified brick, or block. Its chief clay product was common brick, valued at $714,374 or 33.5 per cent of the state total, an increase over 1917 in value of $156,454. The quantity of common brick marketed in 1918 was 69,467,000 brick, a decrease of 12,107,000.

Fire brick, including silica brick was Alabama clay product of second value, a total of 16,579,000, valued at $547,930.

Vitrified brick was third with 25,631,000, valued at $416,463, an increase from 1917 of 4,312,000 in quantity, and in value of $99,549.

Jefferson County was the principal clay-working county, nearly all of the fire and vitrified brick or block produced in the State coming from this county. The principal common-brick-producing counties, named in the order of the value of their output were Jefferson, Montgomery and Talladega.

In tabular form these statistics are given as follows:

Clay products of Alabama, 1913-1918.

PRODUCT.	1913	1914	1915	1916	1917	1918
Brick:						
Common—						
Quantity	130,923,000	110,731,000	70,681,000	85,655,000	81,574,000	69,467,000
Value	$730,148	$638,666	$382,092	$497,446	$557,920	$714,374
Average per M.	$5.58	$5.77	$5.41	$5.81	$6.84	$10.28
Vitrified:						
Quantity	24,188,000	18,679,000	29,018,000	25,143,000	21,819,000	25,631,000
Value	$361,722	$248,525	$374,387	$311,317	$316,914	$416,463
Average per M.	$14.96	$13.31	$12.90	$12.38	$14.87	$16.25
Front—						
Quantity	*	*	5,815,000	6,968,000	*	*
Value	*	*	$58,212	$77,470	*	*
Average per M.	$15.29	$11.42	$10.01	$11.12	$12.17	$20.05
Fancy, value	—	*	—	—	—	—
Fire, value	*	$167,021	$145,585	$278,749	$502,986	$547,980
Draintile, value	$10,802	$6,838	$9,830	*	$17,261	*
Sewer pipe, value	*	*	*	*	*	*
Fireproofing, value	*	*	$62,114	$80,523	$106,700	$163,126
Tile, not drain, value	*	—	—	—	—	—
Pottery:						
Red earthenware, including turpentine cups, value	$11,164	$4,800	$6,741	$13,551	$6,060	$4,023
Stoneware and yellow and Rockingham ware, value	$8,994	$11,742	$8,556	$9,254	$12,671	$11,301
Miscellaneous,† value	$968,751	$496,481	$146,055	$251,991	$488,054	$301,387
Total value	$2,091,581	$1,574,023	$1,198,022	$1,520,301	$2,106,516	$2,159,104
Number of active firms reporting	68	70	65	57	58	49
Rank of state	16	20	24	25	19	18

*Included in "Miscellaneous." †Miscellaneous includes drain tile, sewer pipe, stove lining and silica brick.

Value of the clay products of Alabama in 1917 and 1918, with increase or decrease.

	BRICK AND TILE	POTTERY	TOTAL
1917	2,087,785	18,731	2,106,516
1918	2,143,780	15,324	2,159,104
Increase or decrease			
Value	+ 55,995	− 3,407	+ 52,588
Per cent	+ 2.6	− 18.15	+ 2.4

The pottery products of Alabama are of minor importance, constituting less than 1 per cent of the value of clay products. Production was reported in 1918 by nine firms. The output was valued at $15,324, a decrease of $3,407, or 18.2 per cent as compared with 1917. The products consisted of stone ware and yellow and Rockingham ware, and red earthen ware, including turpentine cups, etc. The latter represents about fifty per cent of the total product. Alabama ranked 18 in the pottery industry in 1918.

Comparison of pottery products in 1917 and 1918.

KIND	1917	1918	Increase or decrease	Percentage
Red earthenware	6,060	4,023	− 2,037	− 33.5
Stoneware and Rockingham ware	12,671	11,301	− 1,370	− 10.8
Total	18,731	15,324	− 3,407	− 18.6

*Including turpentine cups, vases, etc.

Clay Aggregate for Concrete Ships.

One of the most interesting and perhaps important developments of the year was the experiment of building seagoing ships of concrete. In order to make the concrete as light in weight as possible, various light-weight materials including slag, volcanic scoria, and pumice were tried. An aggregate made of burnt clay was found to be the best substitute for stone and gravel in concrete, and its use reduced the weight of the concrete from 150 to 118 pounds per cubic foot. Burnt-clay aggregate in concrete has been used only in shipbuilding, but from the tests of the material in connection with that work there seems to be no reason to suppose that the light-weight aggregate may not find other uses where the weight of ordinary concrete is an objection, as in floors, roofs, and cars.

The following account of the development of this material, including tests of the compressive strength, permeability, and absorptive properties of concrete made with clay aggregate, is taken from the Engineering News-Record of April 24, 1919:

HISTORY AND PROPERTIES OF LIGHT-WEIGHT AGGREGATES.

BURNT CLAY OR SHALE, PRODUCING MATERIAL FULL OF NONCONNECTING CELLS AND MAKING CONCRETE OF HIGH STRENGTH AND LIGHT WEIGHT, DEVELOPED BY GOVERNMENT'S CONCRETE-SHIP ENGINEERS.

Light-weight aggregate made from an artificially burnt shale or clay is now being used for the concrete on all of the Government concrete ships. The concrete so made, in rich mixtures and with a fine-ground cement, weighs from 100 to 118 pounds per cubic foot, and tests in compression from 3,500 to 5,500 pounds per square inch at the end of 28 days. Furthermore, it is impermeable, readily workable, and, so far as has been ascertained, has no defects not common to concrete with any of the more generally used aggregates. This artificial aggregate has been developed by the concrete ship section of the United States Emergency Fleet Corporation, but until now no definite statement of its method of manufacture or of its properties has been given out. Engineering News-Record is permitted here to make public the present knowledge of the material.

Early in the study of the concrete ship it became evident that to compete commercially with wood and steel the concrete must be lighter than the 150 pounds per cubic foot structural mixture commonly used. Naturally, low-weight concrete meant a low-weight aggregate. Many investigations were made into the possibilities of slag and various light, natural aggregates, such as volcanic scoria, pumice, etc., all of which are of a vesicular nature, that is, full of small nonconnecting cells, which reduce weight. In pursuance of these studies it was found that certain clays or shales could be burnt so as to produce a light-weight vesicular product similar in appearance and qualities to the volcanic basalts, but more uniform in character and therefore better fitted for aggregates.

Accordingly, experimental work was started at the Bureau of Standards in the early summer of 1918 on quantity production of this material. The first working plant was a down-draft beehive kiln near Birmingham, Ala., where enough aggregate was turned out to supply the 3,000-ton *Atlantus* launched in December at Brunswick, Ga. Experiments were also carried on in a Portland cement rotary kiln at Ragland, Ala., and initiated at a railroad tunnel kiln at Perth Amboy, N. J., local clays and shales being used at each, but neither progressed beyond the experimental stage. Later, however, two contracts were let for quantity production for the big concrete ships under way; one to the Atlas Portland Cement Co., which makes the aggregate in cement kilns at Hannibal, Mo., and one to the Los Angeles Pressed Brick Co., which made the aggregate in dome kilns formerly used for burning brick. Both plants are now producing aggregates, the Hannibal plant supplying the ships at Wilmington, N. C., Jacksonville, Fla., and Mobile, Ala., and the Los Angeles kilns those at San Diego and San Francisco. In all, 25,000 tons of the aggregate will be required for the present Government program.

The new light-weight aggregate, as has been stated, is an artificially burned clay or shale uniformly filled with small nonconnecting cells. Speaking nontechnically it is a bloated brick, that is, the basic clay or shale from which it is formed, when subjected to a temperature of about 1,800° to 2,000° in a kiln, becomes plastic and sears over on the surface, a coating being formed there which retains the gases generated by the decomposition, under heat, of the contained compounds. This expanding gas blows the brick or the clay ball full of holes and bloats it to several times its original size.

Various clays and shales are the proper quality and consistency for such an aggregate. The material from which the aggregate is made should be rich in compounds of metallic oxides, carbon, sulphur, sodium, potassium, or other equivalent compounds, some of which, when the material is subjected to heat, will either act as a flux in reducing the more refractory compounds or will give off gas at the desired time, or both. The use of clay or shale containing a relatively high percentage of calcium carbonate or magnesium carbonate should be avoided, as such undesirable elements, after being subjected to a temperature sufficiently high to change their form, would be detrimental to the product. The ratio of the fluxing constituents to the nonfluxing constituents can vary within wide limits, but ratios indicating fusibility at comparatively low temperatures may be commercially preferable.

Such material is widely distributed, having been found in Alabama, New Jersey, Missouri, New York, and California, and used commercially in the production of aggregates in those localities. An analysis of a typical clay or shale of which such aggregate is made is as follows:

	Per cent.		Per cent.
SiO_2	60	CO_2	2
Fe_2O_3	8	Alkalies	3
Al_2O_3	19	Water	5
CaO	1		
MgO	1		100
SO_3	1		

Such composition is found both in shales and clays. Both can be used in the manufacture of the aggregate, although the process of manufacture is slightly different. Either one weight about 100 pounds per cubic foot in its natural state.

The resulting product was more or less oxidized on the surface, and lacked the uniformity possible by other methods of burning. However, most of the product was quite satisfactory. The bricks, when sufficiently cool, were taken from the kiln, crushed, and screened.

The coarse aggregate was that which passed the ½-inch screen and was retained on the 3/16, the fine aggregate that passing the 1/16-inch screen to dust. * * * Local coal was used for the fuel in the kilns.

While burning the aggregate at Alton, experiments were also made in burning the same material in a rotary kiln at the plant of the Coosa Portland Cement Co., at Ragland, Ala. In the experiments, the shale from Alton and the shale from the cement company's land were both used. There was practically no difference in the products of the two materials, neither was there much difference in the analysis of the shales. In this experiment the shale was prepared by passing it through Fuller mills and then directly to the kiln in the form of both a dry powder and a slurry. Bricks, also, were made at Alton and shipped to be burned in the rotary kiln with quite satisfactory results. From the experiment, though it was not extensive enough to establish the fact, it would seem that somewhat better results might be expected from the use of a slurry than from the use of a dry feed. Some very excellent material was produced during this experiment, made in an ordinary cement kiln 8 feet in diameter by 125 feet long, using powdered coal as fuel. None of this material was used in the ships.

Further experiments were made at certain other places, both with funnel kilns and with ordinary brick kilns, but none of the material was used in practical work.

Some concern is occasionally expressed as to the permeability of a concrete made with this material. A number of tests have been made, and they all show that such a concrete is as low in absorption and in permeability as concrete made with an apparently more dense aggregate. The material is not porous. While full of holes, it must be remembered that they are nonconnecting holes, so that there is no reason why water should pass through such a concrete, assuming that the aggregate itself is of a dense material. Very few strength tests on the aggregate itself have been made. Recent tests at the University of Pennsylvania laboratory show that in 1-inch cubes it has an average compressive strength of about 1,500 pounds per square inch, with values in test ranging from 1,000 to 2,500 pounds.

Commercial production of the aggregate except for the Government ships has not been started, though there are prospects that one or both of the Government contractors will continue production after the ship requirements are satisfied. There is a company in Kansas City, under the direction of Stephen J. Hayde, which is manufacturing a somewhat similar product known as haydite. This material was used in the concrete superstructure of the freight car recently exhibited in Chicago. Haydite was developed some years ago as the aggregate for sand-lime brick and is produced in a vertical kiln.

The technique of the manufacture of the aggregate is necessarily complicated, as the value of the resulting product depends so much on the quality and moisture content of the raw material, the nature of the preliminary treatment, the degree of heat, and many other details. There is no claim that perfection has been reached in the brief time in which experiments and quantity production have been under way, but the aggregate is uniform and satisfactory in quality and there is every hope that its commercial manufacture is possible. Costs today are not consistent, and are not therefore of much use to those contemplating the use of the aggregate for structural purposes. It seems, however, that the aggregate should be produced at the mill for $3 or $4 per cubic yard, which will weigh in the crushed state * * * in the boll or brick, uncrushed, about 60 pounds per cubic foot.

POTTERY PRODUCERS IN 1918.

Daphne Pottery Co., Daphne, Ala. Works at Daphne (B. & T. No. 2), Baldwin County, Ala.

A. M. Roberts, R. T. Brown, Lessee, Borden Springs, Ala. Cleburne County.

W. I. Mulder, Wetumpka, Ala. Works at Wetumpka (Also B. & T. 29), Elmore County, Ala.

Spruce Pine Sand & Gravel Co., Scharnagel & Dearman, Spruce Pine, Ala. Works at Spruce Pine, Franklin County, Ala.

D. E. Summerford, R. D. 2, Bexar, Ala. Works at Bexar, Franklin County, Ala.

Wm. M. Miller, Spratt, Ala. Works at Marion, Perry County, Ala.

James W. Curry, R. D. No. 5, Centerville, Ala. Works at Bethlehem, Perry County, Ala.

Boggs & Bro., Rock Mills, Ala. Works at Rock Mills, Randolph County, Ala.

M. Miller, Ralph, Ala. Works in Tuscaloosa County, Ala.

BRICK AND TILE PRODUCERS IN 1918.

COMMON BRICK.

Daphne Pottery Co., Daphne, Ala. Works at Daphne, Baldwin County, Ala.

Chattahoochee Brick Co., Eufaula, Ala. Works at Eufaula, Barbour County, Ala.

Birmingham Clay Products Co., Warrior, Ala. Works at Warrior, Blount County, Ala.

W. C. Terrell, Greenville, Ala. Works at Greenville, Butler County, Ala.

W. B. Perdue, Elba, Ala. Works at Elba, Coffee County, Ala.

Consolidated Brick Co., River Falls, Ala. Works at Cawthon, Covington County, Ala.

Cullman Brick Co., Cullman, Ala. Works at Smithdale, Cullman County, Ala.

T. L. Rosser, Douglas, Ala. Works at Douglas, Dale County, Ala.

A. G. Kahn Brick Co., Selma, Ala. Works at Selma, Dallas County, Ala.

Cedar Creek Brick Co., Brewton, Ala. Works at Fishpond, Escambia County, Ala.

W. H. Strong Brick & Veneer Co., Strong & Lovelace, Props., Brewton, Ala. Works at Keego, Escambia County, Ala.

H. F. Horn & Son, Greensboro, Ala. Works at Greensboro, Hale County, Ala.

C. T. Harris, Columbia, Ala. Works at Columbia, Houston County, Ala.

Alabama Brick & Tile Co., Hollywood, Ala. Works at Hollywood, Jackson County, Ala.

Standard Brick Co., Bessemer, Ala. Works at Bessemer, Jefferson County, Ala.

Southern Clay Mfg. Co., 116 West 8th St., Chattanooga, Tenn. Works at Coaldale and Graves, Jefferson County, Ala.

Howard Lane, 47th St. & 8th Ave., N., E. Birmingham, Ala. Works at E. Birmingham, Jefferson County, Ala.

Robertson Brick Co., Ave. B & Sixth St., Birmingham, Ala. Works at E. Birmingham, Jefferson County, Ala.

L. L. Stephenson, Lovick, Ala. Works at Lovick, Jefferson County, Ala.

S. E. Hauerwas Brick Yard, R. F. D. No. 3, Florence, Ala. Works at Florence, Lauderdale County, Ala.

Athens Brick Co., First Nat'l. Bank, Athens, Ala. Works at Athens, Limestone County, Ala.

Tuskegee Normal & Industrial Inst., Tuskegee Institute, Ala. Works at Tuskegee Institute, Macon County, Ala.

Huntsville Brick Co., Inc., Box 253, Huntsville, Ala. Works at Huntsville, Madison County, Ala.

Alabama Lumber & Supply Co., succeeded by Cherry Red Brick Co., Demopolis, Ala., Marengo County.

Gulf Brick & Tile Co., Mobile, Ala. Works at Calvert & Fowl River, Mobile County, Ala.

Jenkins Brick Co., 321 Bell Bldg., Montgomery, Ala. Works at Montgomery, Montgomery County, Ala.

Excelsior Brick Co., 114 N. Perry St., Montgomery, Ala. Works at Montgomery, Montgomery County, Ala.

Decatur Brick & Tile Co., Decatur, Ala. Works at New Decatur, Morgan County, Ala.

E. B. McPherson & Bro., Ashland, Ala. Works at Wedowee, Randolph County, Ala.

Bickerstaff Brick Co., Brickyard, Ala. Works at Brickyard, Russell County, Ala.

Cuba Brick & Pottery Co., York, Ala. Works at Cuba, Sumter County, Ala.

Childersburg Brick Co., Talladega, Ala. Works at Edwards, Talladega County, Ala.

Ala. High Grade Brick Co., Sylacauga, Ala. Sylacauga, Talladega County, Ala.

FRONT BRICK.

L. L. Stephenson, Lovick, Ala. Works at Lovick, Jefferson County, Ala.

FIRE BRICK.

Daphne Pottery Co., Daphne, Ala. Works at Daphne, Baldwin County, Ala.

Ashby Fire Brick Works, Birmingham, Ala. Works at Ashby, Bibb County, Ala.

G. W. Eichelberger & Sons Co., Anniston, Ala. Works at Oxford, Calhoun County, Ala.

Kentucky Southern Refractories Co., Fort Payne, Ala. Works at Fort Payne, DeKalb County, Ala.

Bessemer Fire Brick Co., 1148 Brown-Marx Bldg., Birmingham, Ala. Works at Bessemer and Ensley, Jefferson County, Ala.

Southern Sewer Pipe Works, J. S. Millsom, Mgr., Birmingham, Ala. Works at N. Birmingham, Jefferson County, Ala.

Harbison-Walker Refractories Co., 1808 Farmers Bank Bldg., Pittsburgh, Pa. Works at Fairfield, Jefferson County, Ala.

SILICA BRICK.

Kentucky Southern Refractories Co., Ft. Payne, Ala. Works at Fort Payne, DeKalb County, Ala.

Harbison-Walker Refractories Co., 1808 Farmers Bank Bldg., Pittsburgh, Pa. Works at Fairfield, Jefferson County, Ala.

COAL.

E. W. PARKER AND C. E. LESHER.

INTRODUCTORY.

THE great Appalachian coal region which furnishes over two-thirds of the coal production of the United States and which extends from Ohio and Pennsylvania on the north in a gradually narrowing belt through eastern Kentucky and Tennessee has its southern terminus in a considerably broadened area that occupies a large part of the northern half of Alabama. The coal-bearing formations of Alabama underlie about 8,400 square miles and are divided into four distinct basins, the Coosa, the Cahaba, and the Warrior, named from the rivers which drain them, and the Plateau, which includes Blount, Lookout, and Sand or Raccoon Mountains. By far the most important basin in area and in production is the Warrior, which includes all of Walker County, most of Jefferson, Tuscaloosa, and Fayette counties, and smaller parts of Blount, Cullman, Winston and Marion counties. The area known to contain coal is approximately 4,000 square miles, or one-half the total coal area of the State, and contributes about 85 per cent of the total production.

There are several distinct coal groups in the basin, the most important of which are the Brookwood, the Pratt, and the Mary Lee, designated by the names of their principal beds. The Mary Lee group includes the Blue Creek, the Jagger, and the Newcastle beds, most of which are mined in places. The Brookwood, the Pratt, and the Mary Lee produce most of the coking coal mined in the State, and more than half of all of the coal mined in the district.

The Cahaba Basin, second in importance, is a long narrow syncline, 68 miles long and about 6 miles wide, southeast of the Warrior, and occupies parts of St. Clair, Jefferson, Shelby and Bibb counties. There are many workable beds, and the total quantity of coal in the basin is large. The production is something over 16 per cent of the total for the State.

The Coosa Basin is a deep syncline east of the Cahaba and parallel with it, extending across Shelby and St. Clair counties. It is also long and narrow, 60 miles long by 6 miles wide. It has not been thoroughly explored, but in different parts of the area from two to twelve beds, 3 or more feet in thickness, have been reported.

The Plateau field embraces parts of Blount, Etowah, DeKalb, Cherokee, Marshall, and Jackson counties, and although it has an area underlain by coal four times that of the Cahaba and the Coosa combined, the resources in Alabama are comparatively small. There are four to six beds locally workable. So far as known, the earliest record of the existence of coal in Alabama was made in 1834. The first statement of production in the State is contained in the United States census report for 1840, in which year the production is given at 946 tons. The census report for 1850 does not mention any coal production for the State, and the next authentic record is contained in the census statistics of 1860, when Alabama is credited with an output of 10,200 short tons. The mines of Alabama were probably worked to a considerable extent during the Civil War, but there are no records of the actual production until 1870, for which year the United

States census reports a production of 11,000 tons. Ten years later the production had increased to 323,972 short tons, but the development of the present great industry really began in 1881 and 1882, when attention was directed to the large iron deposits near the city of Birmingham and thus the great "boom" of that city and vicinity was inaugurated. By 1885 the coal production of the State had increased to nearly 2,500,000 tons. Then followed a period of relapse and liquidation, which lasted two years, after which business settled down to a conservative and rational basis and has since developed steadily. In 1902 the coal production of the State reached a total of more than 10,000,000 tons, and reached the maximum of 17,678,522 tons in 1913, since which time there has been a decrease, until 1916, when the maximum of 1913 was exceeded, as may be seen in table below.

PRODUCTION.

The statistics of production in Alabama from 1840 to the close of 1918 are shown in the following table:

Production of coal in Alabama from 1840 to 1918 in short tons.

Year	Quantity	Year	Quantity	Year	Quantity	Year	Quantity
1840	946	1860	10,200	1880	323,972	1900	8,394,275
1841	1,000	1861	10,000	1881	420,000	1901	9,099,052
1842	1,000	1862	12,500	1882	896,000	1902	10,354,570
1843	1,200	1863	15,000	1883	1,568,000	1903	11,654,324
1844	1,200	1864	15,000	1884	2,240,000	1904	11,262,046
1845	1,500	1865	12,000	1885	2,492,000	1905	11,866,069
1846	1,500	1866	12,000	1886	1,800,000	1906	13,107,963
1847	2,000	1867	10,000	1887	1,950,000	1907	14,250,454
1848	2,000	1868	10,000	1888	2,900,000	1908	11,604,593
1849	2,500	1869	10,000	1889	3,572,983	1909	13,703,450
1850	2,500	1870	11,000	1890	4,090,409	1910	16,111,462
1851	3,000	1871	15,000	1891	4,759,781	1911	15,021,421
1852	3,000	1872	16,800	1892	5,529,312	1912	16,100,600
1853	4,000	1873	44,800	1893	5,136,935	1913	17,678,522
1854	4,500	1874	50,400	1894	4,397,178	1914	15,593,422
1855	6,000	1875	67,200	1895	5,693,775	1915	14,927,937
1856	6,800	1876	112,000	1896	5,748,697	1916	18,086,197
1857	8,000	1877	196,000	1897	5,893,770	1917	20,068,074
1858	8,500	1878	224,000	1898	6,535,283	1918	19,184,962
1859	9,000	1879	280,000	1899	7,593,416		
						Total	342,814,050

Coal produced in Alabama, 1912-1918, and increase in 1918.

YEAR	Quantity (Net tons)	Value
1912	16,100,600	$20,829,252
1913	17,687,522	23,083,724
1914	15,593,422	20,849,919
1915	14,927,937	19,066,043
1916	18,086,197	24,859,831
1917	20,068,074	45,616,992
1918	19,184,962	54,752,329
Increase or decrease 1918	883,112	9,135,337
Percentage increase or decrease 1918	— 4.4	+ .20

The production of coal in Alabama in 1918 was 19,184,962 tons, valued at $54,752,329, a decrease, compared with 1917, of 883,112 tons, or 4.4 per cent, in quantity but a gain of $9,135,337, or 20 per cent, in value. No lack of demand interfered with production of coal in Alabama in 1918 nor was there at any time a serious lack of transportation for the coal from mine to market. The greater part of the coal produced in the State is consumed within a comparatively short distance from the mines and car shortage does not affect this field as in other parts of the country. The decrease in 1918 is to be attributed to an actual shortage of mine labor. There were employed in the production of coal in Alabama in 1918, 26,221 men, compared with 28,386 men in 1917, a decrease of 8 per cent. Although the working day was in February, 1918, reduced from 9 to 10 hours to 8 hours, there appears to have been no serious curtailment as a result. The average output per man per day in 1918 was 2.63 tons, a slight gain over the record of 2.59 tons in 1917. The average number of days worked increased slightly, from 273 in 1917 to 278 in 1918, and the annual output per employee increased from 707 tons to 732 tons. The decrease in number of men employed was almost entirely among those working underground.

The largest decrease in production was in Jefferson County, the largest producing county in the State. Walker County, the second in importance, had an increase, as did Blount and Winston counties.

The average value per ton was $2.85 in 1918, as compared with $2.27 in 1917, and with a calculated average on the basis of the Fuel Administration prices of $2.67. The actual average return of $2.85 per ton compares with the estimated average price of the Fuel Administration of $2.83 in the last quarter of the year.

Coal produced in Alabama in 1917.

COUNTY.	Loaded at mines for shipment (net tons).	Sold to local trade and used by employees (net tons)	Used at mines for steam and heat (net tons).	Made into coke at mines (net tons).	Total quantity (net tons).	Number of employees.			Average number of days worked.
						Underground.	Surface.	Total	
Bibb	1,514,154	12,358	98,111	—	1,624,623	1,999	547	2,546	277
Blount	257,159	3,700	5,870	—	266,729	423	122	545	206
Etowah	150,153	1,918	2,194	—	154,265	197	41	238	271
Jefferson	7,089,174	229,060	300,555	2,834,304	10,453,093	11,746	2,731	14,477	291
St. Clair	813,070	3,406	20,519	—	836,995	643	91	734	290
Shelby	731,082	6,847	43,929	—	781,858	1,161	309	1,470	256
Tuscaloosa	193,800	87,528	36,642	605,765	923,735	1,227	315	1,542	240
Walker	4,364,113	151,560	123,649	205,158	4,844,480	5,170	1,193	6,363	248
Winston	43,456	444	—	—	43,900	118	20	138	176
Other counties‡	116,555	3,111	10,264	—	129,930	241	92	333	223
Small mines	—	8,466	—	—	8,466	—	—	—	—
	15,272,716	508,398	641,733	3,645,227	20,068,074	22,925	5,461	28,386	273

‡Includes Cullman, Jackson, and Marion counties.

Value of coal produced in Alabama in 1917.

COUNTY.	Loaded at mines for shipment.	Sold to local trade and used by employees.	Used at mines for steam and heat.	Made into coke at mines.	Total value.	Average value per ton.
Bibb	$3,669,103	$31,561	$224,880	—	$3,925,544	$2.42
Blount	659,832	9,300	16,748	—	685,880	2.57
Etowah	320,239	3,702	4,523	—	328,464	2.13
Jefferson	15,445,288	382,805	653,968	$8,167,903	24,649,959	2.36
St. Clair	1,560,721	6,764	30,320	—	1,597,805	1.91
Shelby	2,038,669	19,034	119,532	—	2,177,235	2.78
Tuscaloosa	453,778	190,742	68,182	1,234,479	1,947,181	2.11
Walker	8,786,741	347,490	198,182	470,145	9,802,558	2.02
Winston	124,307	1,100	—	—	125,407	2.36
Other counties*	332,817	7,851	15,525	—	356,193	2.74
Small mines	—	20,766	—	—	20,766	2.45
	33,391,495	1,021,115	1,331,855	9,872,527	45,616,992	2.27
Average value per ton	2.19	2.01	2.08	2.71	2.27	—

*Includes Cullman, Jackson, and Marion counties.

Coal produced in Alabama in 1918.

COUNTY.	Loaded at mines for shipment (net tons).	Sold to local trade and used by employees (net tons).	Used at mines for steam and heat (net tons).	Made into coke at mines (net tons).	Total quantity (net tons).	Number of employees.			Average number of days worked.
						Underground.	Surface.	Total.	
Bibb	1,294,288	12,655	67,605	—	1,374,548	1,674	438	2,112	267
Blount	301,358	4,155	9,582	—	315,095	340	160	500	280
Etowah	126,082	1,661	2,845	—	130,588	196	41	237	290
Jefferson	7,261,492	96,540	275,792	1,746,133	9,379,957	10,199	2,523	12,722	290
St. Clair	779,017	6,635	27,855	18,841	832,348	576	240	816	296
Shelby	695,127	8,216	40,768	—	744,111	961	219	1,180	288
Tuscaloosa	690,719	10,026	27,331	304,629	1,032,705	1,014	385	1,399	280
Walker	4,715,284	159,283	126,111	155,591	5,156,269	5,264	1,499	6,763	260
Winston	73,707	120	2,700	—	76,527	101	47	148	288
Other counties*	124,967	2,483	13,150	—	140,600	259	85	344	220
Small mines	—	2,264	—	—	2,264	—	—	—	—
	16,061,991	304,038	593,739	2,225,194	19,184,962	20,584	5,637	26,221	278

*Cullman, Jackson, and Marion.

Value of coal produced in Alabama in 1918.

COUNTY.	Loaded at mines for shipment.	Sold to local trade and used by employees.	Used at mines for steam and heat.	Made into coke at mines.	Total value.	Average value per ton.
Bibb	$4,209,392	$38,637	$175,097	—	$4,423,126	$3.22
Blount	950,847	11,539	28,274	—	990,660	3.14
Etowah	399,863	4,821	8,251	—	412,935	3.16
Jefferson	18,825,779	222,121	1,057,949	$6,683,093	26,788,942	2.86
St. Clair	2,119,176	15,993	62,636	69,712	2,267,517	2.72
Shelby	2,373,773	29,544	132,330	—	2,535,647	3.41
Tuscaloosa	2,179,603	36,885	61,308	843,665	3,121,461	3.02
Walker	12,409,841	326,935	293,103	442,245	13,472,124	2.61
Winston	250,323	414	9,180	—	259,917	3.40
Other counties*	419,825	18,140	36,744	—	474,709	3.38
Small mines	—	5,291	—	—	5,291	2.34
	44,138,422	710,320	1,864,872	8,038,715	54,752,329	—
Average value per ton	2.75	2.34	3.14	3.61	2.85	2.85

*Cullman, Jackson, and Marion.

Coal produced in Alabama, 1914-1918, in net tons.

COUNTY.	1914	1915	1916	1917	1918	Increase or decrease, 1918.
Bibb	1,674,846	1,534,534	1,498,856	1,624,623	1,374,548	— 250,075
Blount	150,384	165,789	*212,111	266,729	315,095	+ 48,366
Cullman, Jackson, and Marion	81,041	†68,890	†80,158	129,930	140,600	+ 10,670
Etowah	156,909	177,368	158,601	154,265	130,538	— 23,727
Jefferson	7,936,145	7,579,503	9,884,869	10,453,093	9,379,957	— 1,073,136
St. Clair	752,588	774,058	792,170	836,995	832,348	— 4,647
Shelby	498,914	589,412	618,638	781,858	744,111	— 37,747
Tuscaloosa	858,899	787,586	940,796	923,735	1,032,705	+ 108,970
Walker	3,450,185	3,221,955	3,982,028	4,844,480	5,156,269	+ 311,789
Winston	31,618	26,627	22,415	43,900	76,527	+ 32,627
Small mines	1,893	*2,265	560	8,466	2,264	— 6,202
	15,593,422	14,927,937	18,086,197	20,068,074	19,184,962	— 883,112
Total value	$20,849,919	$19,066,043	$24,859,331	$45,616,992	$54,752,329	+$9,135,337

*Includes Jackson county. †Marion county only.

LABOR STATISTICS.

Men employed in the coal mines of Alabama, 1918.

Underground	20,584
Surface	5,637
Total	26,221

Statistics of labor employed in coal mines of Alabama, 1908-1918.

YEAR	Number of days active.	Average Number Employed.
1908	222	19,197
1910	249	22,210
1911	227	22,707
1912	245	22,613
1913	255	24,552
1914	226	24,042
1915	228	22,591
1916	262	25,308
1917	273	28,386
1918	278	26,221

Average production per man compared with hours worked per day, and average number of days worked 1910-1918.

Year	8 hours		9 hours		10 hours		All others	Total		Average Tonnage	
	Mines	Men	Mines	Men	Mines	Men	Men	Men	Days Worked	Per Year	Per Day
1910	18	766	36	2,633	184	17,306	1,525	22,230	249	725	2.91
1911	15	550	50	5,345	102	12,628	4,184	22,707	227	662	2.92
1912	11	338	46	4,145	107	13,938	4,192	22,613	245	712	2.91
1913	13	420	36	2,496	135	18,185	3,451	24,552	255	720	2.82
1914	14	646	24	3,546	150	18,115	1,735	24,042	226	648	2.87
1915	13	369	44	4,402	133	17,109	711	22,591	228	661	2.96
1916	9	306	40	2,724	132	20,736	1,902	25,308	262	715	2.73
1917	33	3536	27	1,900	143	20,766	2,184	28,386	273	707	2.59
1918	235	24129	3	72	8	872	1,148	26,221	278	732	2.62

Strikes and Suspensions.

Statistics of labor strikes in the coal mines of Alabama in 1917 and 1918.

1917			1918		
Number of men on strike	Total days lost	Average number of days lost per man	Number of men on strike	Total days lost	Average number of days lost per man
1835	10220	6	1952	3259	2

MINING METHODS.

The term "mining method" as used here refers to the manner in which the coal is broken down in the mine and not to the system of mining, or by room and pillar or long wall. In the mine the coal is either blasted from a solid face—shot from the solid—as in hard-rock mining, or is shot loose or otherwise broken down after a preliminary cut into the coal has been made. This cut may be made by hand or machine. Underground methods are therefore classified as shot from the solid, mined by hand and mined by machines. An increasing quantity of coal is being recovered each year by stripping the cover from the bed in open pits by steam shovels. The bed thus exposed is for the most part shattered by powder and shoveled into cars by hand, although in places it is picked up directly by small steam shovels.

Opposition to shooting from the solid has developed, because it is injurious to the mining property in that the unusual charges of powder weaken the roof and pillars, which increases the liability to falls of roofs and coal, the most prolific cause of fatal accidents to coal miners. Another objection to this method is that the heavy charges of powder required to blow down the coal where it has not been previously undercut or sheared cause the production of a very high proportion of fine coal and render the lump coal so friable that it disintegrates in handling and in transportation. With the growing use of mechanical stokers and of powdered coal the latter objection is losing much of its force, but the danger attending the method has been in no wise diminished, and it is forbidden by law in some of the coal-mining states. There was a slight increase in the total output shot from the solid in 1916 compared with 1915.

Statistics of bituminous coal recovered from steam shovel pits, appear for the first time in 1916. One shovel only was active in Alabama in 1915.

Quantity and percentage of coal mined by different methods in Alabama in 1917 and 1918, in short tons.

YEAR	Mined by hand	Percentage	Shot off the solid	Percentage	Mined by machines	Percentage	From steam shovel pits	Percentage	Not reported	Percentage	Total production
1917	5,340,112	26.6	8,419,146	42.0	6,062,744	30.1	231,217	1.2	14,855	0.1	20,068,074
1918	4,240,978	22.1	8,496,782	44.3	5,951,547	31.	231,078	1.2	264,627	1.4	19,184,962

Bituminous coal mined by machines in Alabama in 1917 and 1918.

YEAR	Number of machines in use	Number of tons mined by machines	Total tonnage of Alabama	Percentage of total product mined by machines
1917	332	6,062,744	20,068,074	30.1
1918	403	5,951,547	19,184,962	31.0

COAL-WASHING OPERATIONS.

Not all coal can be cleaned by hand picking. Some coal beds or parts of beds have layers or benches of slate and bone or contain more than the allowable quantity of sulphur in the form of iron pyrite so thoroughly mixed with the coal that crushing is necessary to free the coal from the refuse. To clear such coal washing is resorted to and the coal, being lighter than the refuse, is separated by currents of water. Coal is also cleaned in the dry state.

Alabama leads in the quantity of coal washed, almost 43.5 per cent of the total quantity, so treated in 1918 being from the State.

Coal washed at the mines in Alabama in 1917 and 1918, with quantity of washed coal and refuse obtained from it, short tons.

YEAR	Quantity of coal washed	Quantity of cleaned coal	Quantity of refuse	Percentage of cleaned coal to total state output	Percentage increase or decrease in coal washed
1917	12,714,868	11,408,051	1,306,817	56.8	+15.9
1918	10,895,953	9,449,901	1,446,952	49.3	—14.2

AVERAGE VALUE OF ALABAMA COAL.

Average value per short ton for coal at the mines in Alabama since 1909.

1909	1910	1911	1912	1913	1914	1915	1916	1917	1918
$1.19	$1.26	$1.27	$1.29	$1.31	$1.34	$1.28	$1.37	$2.27	$2.85

DISTRIBUTION AND CONSUMPTION.

C. E. LESHER.

OBJECT AND SCOPE OF REPORT.

THE object of this report is to furnish statistics showing the internal distribution of the coal produced in the United States, the principal purposes for which it is used, and the quantities consumed in each State. For 34 years the Geological Survey has collected and published the statistics of the production and value of coal, but this is the first comprehensive investigation made to show in detail where the coal produced is consumed. The competition between the bituminous coal-producing districts in the United States for the domestic markets is as active as that between the coal-exporting nations of the world for the foreign markets. The extent and nature of the demand in the domestic markets are moreover of ever-present interest to our coal industry, because more than 95 per cent of the coal produced in the United States is used within the country.

The largest problem confronting the exploiters of a coal deposit is, of course, that of markets, and whoever produces or sells the coal must consider in a broad way the possible markets not only as to quantity but as to quality. For blacksmithing and for making coal gas, coals that have special chemical properties are required, and domestic users have established preferences based on both experience and prejudice. By far the largest part of the coal supplied to every market is used for raising steam, and the statistics of coal used for this purpose in any and every part of the country are therefore of primary interest to those who are engaged in the coal industry. The limitations of time and funds available for the work on this report have permitted only incidental consideration of the markets for bituminous coals of particular kinds. The distribution of coal from West Virginia, for instance, is shown for the State as a unit, though there is a great difference between the kinds of coal mined there and as great a difference between the markets reached by the coal.

The cost of mining, the largest element of which—the cost of labor—is now practically controlled either directly or indirectly by the labor unions, and the cost of transportation, regulated by the Government through the Interstate Commerce Commission, impose definite limitations upon the markets that may profitably be reached by any coal. It is fast becoming the rule that the deciding factor in the purchase of coal for most uses is its cost in terms of the work to be performed.

Statistics of the movement of coal to market are of particular interest to those who are considering railroad rates. The quantity of coal carried by the railroads is larger than that of any other single commodity, and it is the coal traffic that has made possible the profitable operation of a number of important railroads. It is to the interest of the coal-carrying roads, within the limits of fair play, to keep in balance the movement from the competing fields. Here, again, data of the kind given in this report are needed as a basis of intelligent action.

The report of the Geological Survey on the distribution and consumption of coal in 1915, the first attempt to present such detailed statistics, was so generally well received and appeared to fill such a timely need that it was hoped to continue the statistics for succeeding years. The work of supplying the demand for statistics of coal and coke that followed the entrance of the United States into the war, in April, 1917, was so heavy that it precluded any attempt to compile data on distribution and consumption for 1916. The advent of the United States Fuel Administration, late in 1917, with its demand for statistical information, presented a special need and afforded a means of comprehensive study of the statistics of distribution for 1917. The particular need for these data by the Fuel Administration was connected with the proposed allotment of bituminous coal from producing districts to consuming States, and the zone system of distribution. The work of compilation was undertaken by the writer in his capacity of geologist in charge of coal statistics for the Geological Survey and director of the bureau of statistics of the Fuel Administration. The data originally compiled in the early months of 1918 have all been rechecked and are presented as nearly as possible in the form of the report for 1915.

Complete and absolutely accurate reports of distribution are impossible to obtain and any attempt to compile such statistics as this report contains must include estimates, but it is believed that these data in all important respects are accurate and that some of the shortcomings of the statistics for 1915 have been overcome.

DISTRIBUTION OF COAL PRODUCED IN ALABAMA IN 1918.

IN ITS output of coal Alabama is the most productive State in the South, and it is centrally located as regards the markets of the Southern States. In 1918 the Southern railroads used nearly 5,500,000 tons of Alabama coal, which is 27 per cent of the production in Alabama and nearly 20 per cent of the consumption by the railroads in the South. In addition to that taken by the railroads, more than 11,500,000 tons, or more than half the total output, was used in the State; 1,563,467 tons or 8.1 per cent of the output, was shipped to other States; and 786,000 tons, or 4 per cent, went to tidewater for foreign and domestic cargo and bunker fuel. Of the coal shipped outside the State for commercial use the greater part, about 1,675,000 tons, reached the Mississippi Valley markets in Louisiana and Mississippi and in a less amount those in Missouri, Tennessee, and Arkansas. On the east, Georgia and Florida are the best consumers of Alabama coal.

The program of the Fuel Administration did not contemplate material reduction in 1918 of the area in which coal from Alabama is normally distributed but rather planned to take care of the industrial and other needs of the State of Alabama primarily with Alabama coal and to supplement the shipments from this State to other near-by markets that are normally dependent on coal from Alabama by supplies from other fields, such as Tennessee, Virginia, and western Kentucky. How this program worked out is shown by the statistics of distribution for 1917 and 1918. As in 1917, more than half the coal produced in Alabama in 1918 was used in the State. With the exception of those to Florida, shipments to all other States were less in 1918 than in 1917, as were deliveries to railroads. The special efforts of the Fuel Administration to increase the use of Alabama coal at tidewater points, for the relief of northern ports, resulted in an increase of deliveries to tidewater of more than 200,000 tons.

Distribution of bituminous coal produced in Alabama, 1917, and 1918 by routes and destination.

YEAR	All-rail shipments.						Shipped to tidewater.		
	Used within the State		Shipped to other States		Used by railroads.				
	Quantity (net tons)	Percentage of production.	Quantity (net tons)	Percentage of production.	Quantity (net tons)	Percentage of production.	Quantity (net tons)	Percentage of production.	Total quantity (net tons)
1917	11,222,916	56	2,622,000	13	5,641,254	28	581,904	3	20,068,074
1918	11,627,695	60.6	1,563,467	8.2	5,207,184	27	786,616	4.1	19,184,962

The greater part of the coal produced in Alabama is used within the State or is taken by railroads in the South. Shipments to neighboring states represented in 1918 only 8.28 per cent and shipments to tidewater only 4 per cent of the total output.

Distribution of coal produced in Alabama in 1917-18.

	Quantity (net tons)		Percentage of total	
	1917	1918	1917	1918
Used in Alabama:				
Sold to local trade, not shipped	508,398	304,038		
Used at mines for steam and heat	641,733	593,739		
Made into coke at mines	3,645,227	2,225,194		
Shipped to Alabama points	6,427,558	8,504,724		
	11,222,916	11,627,695	55.9	60.7
Shipped to other states:				
Arkansas	15,000	1,512		
Florida	115,000	173,290		
Georgia	585,000	556,585		
Louisiana	925,000	360,700		
Mississippi	750,000	341,575		
Missouri	7,000	———		
Tennessee	175,000	94,575		
Texas	50,000	35,230		
	2,622,000	1,563,467	13.1	8.1
Delivered to railroads by all-rail routes	5,641,254	5,207,184	28.1	27.1
Shipped to tidewater	581,904	786,616	2.9	4.1
	20,068,074	19,184,962	100.0	100.0

Distribution of Alabama Coal dumped at South Atlantic and Gulf Ports in 1917 and 1918.

YEAR	Cargo, foreign	Bunker		Total
		Foreign	Coastwise	
1917	49,896	378,101	153,907	581,904
1918	127,847	439,473	208,896	776,216

CONSUMPTION.

Bituminous coal of domestic origin consumed in Alabama, 1917 and 1918, in net tons.

(Railroad fuel and bunker fuel for ocean vessels not included in this table.)

YEAR	Used at mines for steam and heat.	Used in manufacture of beehive coke.	Used in manufacture of by-product coke.	Used in manufacture of coal gas.	Used for domestic and industrial purposes, including electrical utilities	Total coal consumed.
1917	641,733	3,658,598	3,980,243	90,886	3,082,456	11,453,916
1918	593,739	2,949,992	3,877,634	80,477	4,473,585	11,975,377

Coal consumed in Alabama in 1917, according to source.

(Exclusive of fuel for railroads and steamships.)

SOURCE	Quantity net tons
Alabama	11,222,916
Kentucky	150,000
Tennessee	66,000
Virginia	15,000
Total bituminous coal	11,453,916
Pennsylvania anthracite	1,084
Total	11,455,000

Shipments by rail and water.

RAILROAD	Tons
Alabama Central	74,464
Atlanta, Birmingham & Atlantic	185,297
Birmingham Southern	3,144,419
Central of Georgia	767,618

Distribution of bituminous coal produced in Alabama, 1917, and 1918 by routes and destination.

YEAR	All-rail shipments.						Shipped to tidewater.		
	Used within the State		Shipped to other States		Used by railroads.				
	Quantity (net tons)	Percentage of production.	Quantity (net tons)	Percentage of production.	Quantity (net tons)	Percentage of production.	Quantity (net tons)	Percentage of production.	Total quantity (net tons)
1917	11,222,916	56	2,622,000	13	5,641,254	28	581,904	3	20,068,074
1918	11,627,695	60.6	1,563,467	8.2	5,207,184	27	786,616	4.1	19,184,962

The greater part of the coal produced in Alabama is used within the State or is taken by railroads in the South. Shipments to neighboring states represented in 1918 only 8.28 per cent and shipments to tidewater only 4 per cent of the total output.

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Sold to local trade, not shipped	508,398	304,038		
Used at mines for steam and heat	641,733	593,739		
Made into coke at mines	3,645,227	2,225,194		
Shipped to Alabama points	6,427,558	8,504,724		
	11,222,916	11,627,695	55.9	60.7
Shipped to other states:				
Arkansas	15,000	1,512		
Florida	115,000	173,290		
Georgia	585,000	556,585		
Louisiana	925,000	360,700		
Mississippi	750,000	341,575		
Missouri	7,000	—		
Tennessee	175,000	94,575		
Texas	50,000	35,230		
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Distribution of Alabama Coal dumped at South Atlantic and Gulf Ports in 1917 and 1918.

YEAR	Cargo, foreign	Bunker		Total
		Foreign	Coastwise	
1917	49,896	378,101	153,907	581,904
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CONSUMPTION.

Bituminous coal of domestic origin consumed in Alabama, 1917 and 1918, in net tons.

(Railroad fuel and bunker fuel for ocean vessels not included in this table.)

YEAR	Used at mines for steam and heat.	Used in manufacture of beehive coke.	Used in manufacture of by-product coke.	Used in manufacture of coal gas.	Used for domestic and industrial purposes, including electrical utilities	Total coal consumed.
1917	641,738	3,658,598	3,980,248	90,886	3,082,456	11,453,916
1918	593,739	2,949,992	3,877,634	80,477	4,473,535	11,975,377

Coal consumed in Alabama in 1917, according to source.

(Exclusive of fuel for railroads and steamships.)

SOURCE	Quantity net tons
Alabama	11,222,916
Kentucky	150,000
Tennessee	66,000
Virginia	15,000
Total bituminous coal	11,453,916
Pennsylvania anthracite	1,084
Total	11,455,000

Shipments by rail and water.

RAILROAD	Tons
Alabama Central	74,464
Atlanta, Birmingham & Atlantic	185,297
Birmingham Southern	3,144,419
Central of Georgia	767,618

Illinois Central	116,864
Louisville & Nashville	3,555,290
Mary Lee	21,190
Mobile & Ohio	326,382
Nashville, Chattanooga & St. Louis	18,037
St. Louis-San Francisco	2,293,246
Seaboard Air Line	45,452
Southern	4,017,868
Thomas & Sayreton	476,467
Woodstock & Blocton	101,730
Woodward Iron Co. Railroad	60,347
WATER	
Warrior River	67,945
Grand total	15,272,716

Coal consumed in Alabama in 1918, according to source.

(Exclusive of fuel for railroads and steamships.)

SOURCE	Quantity net tons
Alabama	11,627,695
Kentucky, Western	97,434
Tennessee and Georgia	217,244
Virginia, Southwestern	12,285
Illinois	20,719
Total bituminous coal	11,975,377

Shipments by rail and water.

RAILROAD	Tons
Alabama Central	37,959
Atlanta, Birmingham & Atlantic	185,866
Birmingham Southern	2,438,657
Central of Georgia	686,442
Louisville & Nashville	3,801,002
Mary Lee	144,637
Mobile & Ohio	529,584
Nashville, Chattanooga & St. Louis	17,565
St. Louis-San Francisco	2,602,958
Seaboard Air Line	95,025
Southern	4,748,566
Thomas & Sayreton	559,666
Woodstock & Blocton	175,739
Woodward Iron Co. Railroad	5,064
WATER	
Warrior River	33,261
Grand total	16,061,993

Character of opening at bituminous coal mines in Alabama in 1918.

CLASS	Production (net tons)	MINES					
		Total	Shaft	Slope.	Drift.	Strip.	Not specified
1	8,671,854	23	4	14	4	—	1
2	2,923,182	22	5	18	2	—	2
3	4,045,585	56	—	30	21	2	3
4	3,098,327	116	1	41	57	3	14
5	446,014	96	2	14	33	1	46
	19,184,962	313	12	112	117	6	66

Bituminous coal produced in Alabama in 1918, by name or number of bed or seam.

Name or number of bed or seam.	Number of mines	Production	
		Net tons	Percent. of state total
Altoona	5	128,538	0.67
America	5	283,688	1.48
America and Pratt	3	141,313	.74
Battle Creek	1	15,565	.08
Belmont	1	2,754	.01
Black Shale	1	3,200	.02
Blue Creek	5	424,963	2.22
Blue Creek and Little Jagger	1	73,184	.38
Black Creek	37	1,421,316	7.41
Brookwood	2	38,066	.20
Carter	3	22,209	.12
Coal City, Marion, and Broken Arrow	3	70,832	.37
Clark	1	54,924	.29
Clark and Gholson	4	239,430	1.25
Corona	18	571,677	2.98
Gholson	1	94,848	.49
Gould	1	3,919	.02
Gwinn	1	4,425	.02
Harkness	5	288,726	1.50
Helena	6	364,855	1.90
Jagger	24	1,261,958	6.58
Jefferson	5	364,358	1.90
Mary Lee	67	4,717,978	24.59
Mammoth	2	416,655	2.17
Marion	2	53,426	.28
Maylene	1	30,548	.16
Montevallo	2	152,478	.79
Milldale	6	647,691	3.38
Milldale, Carter, and Brookwood	1	138,481	.72

Bituminous Coal Produced in Alabama in 1918, by name or number of bed or seam.—Continued.

Name or number of bed or seam.	Number of mines	Production	
		Net tons	Percent. of state total
New Castle	2	311,024	1.62
Nickle Plate	14	567,714	2.96
Pratt	31	4,590,898	23.93
Pratt and Nickle Plate	5	229,522	1.20
Rosa	3	99,023	.52
Straven	1	26,067	.14
Thompson	6	564,921	2.94
Wadsworth	2	4,611	.02
Water Works	1	28,980	.15
Woodstock	4	333,180	1.74
Youngblood	2	243,491	1.27
Yessick	1	7,100	.04
Not specified	27	146,541	.75
	313	19,184,962	

Distribution of all-rail shipments of bituminous coal from August 3, 1918, to February 1, 1919, of the South Atlantic, and Southern States. by consuming states and classes of consignees.

Consuming State	Percentage of shipments to classes of consignees				
	United States Government institutions	State and county institutions	Public utilities, gas and electricity	Retail coal dealers	Industries, including iron and steel
South Atlantic and Southern States:					
Alabama	1.1	.3	3.8	6.4	88.4
Arkansas	3.8	1.5	14.4	31.9	48.4
Delaware	1.2	1.6	20.0	9.2	68.0
Maryland and District of Columbia	23.1	2.1	10.3	23.9	40.6
Florida	5.4	2.3	26.2	19.3	46.8
Georgia	4.0	1.1	14.4	30.2	50.3
Kentucky	2.3	1.4	10.0	46.4	39.9
Louisiana	7.0	2.3	20.3	31.0	39.4
Mississippi	1.8	3.2	19.2	33.3	42.5
North Carolina	2.5	.9	12.8	29.7	54.1
South Carolina	14.9	.3	9.5	22.0	53.3
Oklahoma	1.4	.7	5.3	43.9	48.7
Tennessee	.4	1.3	12.6	34.4	51.3
Texas	2.6	1.4	14.7	31.3	50.0
Virginia	9.8	.4	11.2	25.4	53.2
West Virginia	7.6	.3	15.4	13.6	63.1

Bituminous coal produced in Alabama in 1917 and 1918, according to classes of mines.

YEAR	First class (mines producing more than 200,000 tons).					Second class (mines producing from 100,000 to 200,000 tons).					Third class (mines producing from 50,000 to 100,000 tons).				
	Mines		Quantity			Mines		Quantity			Mines		Quantity		
	Number	Percentage	Total (net tons)	Average per mine (net tons)	Percentage	Number	Percentage	Total (net tons)	Average per mine (net tons)	Percentage	Number	Percentage	Total (net tons)	Average per mine (net tons)	Percentage
1917	28	9.7	11,040,920	394,319	55.0	27	9.4	3,458,017	128,075	17.2	43	14.9	3,206,216	74,563	16.0
1918	23	7.3	8,671,854	377,037	45.2	22	7.0	2,928,182	132,872	15.2	56	17.9	4,045,585	72,243	21.1

YEAR	Fourth class (mines producing from 10,000 to 50,000 tons).					Fifth class (mines producing less than 10,000 tons).					Total.		
	Mines		Quantity			Mines		Quantity					
	Number	Percentage	Total (net tons)	Average per mine (net tons)	Percentage	Number	Percentage	Total (net tons)	Average per mine (net tons)	Percentage	Mines.	Quantity (net tons)	Average per mine (net tons)
1917	77	26.9	2,023,857	26,284	10.1	112	39.1	339,068	3,027	1.7	287	20,068,078	69,924
1918	116	37.1	3,098,327	26,710	16.2	96	30.7	446,014	4,646	2.3	313	19,184,962	61,294

COAL PRODUCERS IN 1918.

Bessemer Coal, Iron & Land Co., Birmingham, Ala. Mines Belle Ellen 2, 7, 8, Bibb County, Ala.

Bibb Coal Co., R. F. D. No. 2, Blocton, Ala. Mine at Norris, Bibb County, Ala.

Blocton-Cahaba Coal Co., Coleanor, Ala. Mine at Coleanor, Bibb County, Ala.

Cahaba Red Ash Coal Co., West Blocton, Ala. Mine at Welch, Bibb County, Ala.

Cahaba Southern Coal Mining Co., Hargrove, Ala. Mine at Hargrove, Bibb County, Ala.

J. W. Cobb, Birmingham, Ala. Mine at Cobbs, Bibb County, Ala.

Galloway Coal Co., 24 N. 2nd St., Memphis, Tenn. Mine at Garnsey, Bibb County, Ala.

Hills Creek Mining Co., Blocton, Ala. Mine at Hills Creek, Bibb County, Ala.

Julian Lime Co. Mine at Cobbs, Bibb County, Ala.

Little Cahaba Coal Co., Piper, Ala. Mines at Piper No. 1 and Piper No. 2, Bibb County, Ala.

Red Eagle Coal Co., American Trust Bldg., Birmingham, Ala. Mine at Red Eagle, Bibb County, Ala.

Red Feather Coal Co., R. R. No. 1, Blocton, Ala. Mine at Red Feather, Bibb County, Ala.

Roden Coal Co., Marvel, Ala. Mines at Marvel No. 1 and Marvel No. 3, Bibb County, Ala.

Tennessee Coal, Iron & R. R. Co., Birmingham, Ala. Mine at Blocton No. 7, Bibb County, Ala.

D. B. Gore Co., R. R. No. 4, Altoona, Ala. Mine at Garls Gap, Blount County, Ala.

Inland Coal & Iron Co., 1807 Jefferson County Bank Bldg., Birmingham, Ala. Mine at Inland No. 1, Blount County, Ala.

Lehigh Coal Co., Lehigh, Ala. Mine at Lehigh, Blount County, Ala.

Little Black Warrior Coal Co., Birmingham, Ala. Mine at Fairchild, Blount County, Ala.

Warrior Black Creek Coal Co., Warrior, Ala. Mine at Wyota No. 2, Blount County, Ala.

Stouts Mountain Coal Co., Birmingham, Ala. Mine at Stouts Mountain, Cullman County, Ala.

Altoona Coal Co., Altoona, Ala. Mines at Altoona Drift No. 4 and Van Zandt, Etowah County, Ala.

Cherokee Coal Co., Altoona, Ala. Mine at Faithful, Etowah County, Ala.

Gulf States Steel Co., Brown-Marx Bldg., Birmingham, Ala. Mine Altoona Drift No. 4, Etowah County, Ala.

W. C. Rust Coal Co., succeeded by Champion Coal Co., Birmingham, Ala. Mine at Line Creek, Etowah County, Ala.

R. V. Huff, Altoona, Ala. Mine at Huff, Etowah County, Ala.

Kings Mountain Coal Co., 619 Hamilton National Bank Bldg., Chattanooga, Tenn. Mine Widow's Creek, Jackson County, Ala.

Pierce Coal & Lumber Co., Pierceton, Ala. Mine Pierce-Belmont, Jackson County, Ala.

Ajax Coal Co., D. H. Brown & Co., Birmingham, Ala. Mine at Jefferson County, Ala.

The Alabama Co., Birmingham, Ala. Mine Lewisburg (Mary Lee) Jefferson County, Ala.

Beltona Coal & Mining Co., Beltona, Ala. Mine at Beltona, Jefferson County, Ala.

Bibby Coal Shale & Clay Co., Littleton, Ala. Mine at Wigan No. 3, Jefferson County, Ala.

Sandstone Coal Mining Co., Birmingham, Ala. Mine at Jefferson County, Ala.

Birmingham Clay Products Co.

Birmingham Water Works Co., 2114 First Ave., Birmingham, Ala. Mine at Cahaba, Jefferson County, Ala.

Brookside-Pratt Mining Co., Brown-Marx Bldg., Birmingham, Ala. Mines at Buckeye No. 1, Coalburg, Pickney No. 2, Riverside No. 1, Riverside No. 2, Stockton, Carcliff No. 2, Carcliff No. 3, Pinckney No. 4, Jefferson County, Ala.

Central Alabama Coal Co., Kimberly, Ala. Mines at Kimberly No. 2 and Kimberly No. 3, Jefferson County, Ala.

Crescent Coal Co., Birmingham, Ala. Mine at Seloca, Jefferson County, Ala.

Donaldson-Stobert Coal Co., Birmingham, Ala. Mine at Pacoba, Jefferson County, Ala.

East Pratt Coal Co., Woodward Bldg., Birmingham, Ala. Mine at Clift, Jefferson County, Ala.

Eldorado Coal Co., 715 American Trust Bldg., Birmingham, Ala. Mines at Coalburg No. 10 and Walmore No. 1, Jefferson County, Ala.

G. D. Etter, Jr., Warrior, Ala. Mine at Etter, Jefferson County, Ala.

Flat Creek Mining Co., Quinton, Ala. Mine at North Labuco, Jefferson County, Ala.

Franklin Coal Mining Co., P. O. Box 887, Birmingham, Ala. Mines at Blossburg and Powhatan, Jefferson County, Ala.

Gillespie Coal Co., 2400 2nd Ave., Birmingham, Ala. Mine at Gillespie, Jefferson County, Ala.

Imperial Coal & Coke Co., American Trust Bldg., Birmingham, Ala. Mine at Bradford, Jefferson County, Ala.

The Thomas Furnace Co., Aubrey, Ala. Mine at Weller, Jefferson County, Alabama.

Mabel Mining Co., Warrior, Ala. Mine at Rio Del, Jefferson County, Ala.

Majestic Coal Co., American Trust Bldg., Birmingham, Ala. Mine at Majestic, Jefferson County, Ala.

Montgomery Coal Co., Warrior, Ala. Mine at Jefferson County, Ala.

Newcastle Coal Co., P. O. Box 313, Birmingham, Ala. Mine at Newcastle, Jefferson County, Ala.

New Found Creek Coal Co., R. R., Box 70, Morris, Ala. Mine at Eulamo, Jefferson County, Ala.

North Birmingham Coal Co., Sayreton, Ala. Mine at No. 1 Ohara, Jefferson County, Ala.

North Pratt Coal Co., R. R., No. 1, Adamsville, Ala. Mine at Hill House, Jefferson County, Ala.

Pratt Consolidated Coal Co., Birmingham, Ala. Mines at Arcadia, Banner, Crocker, Eldorado, Jett, Littleton, Maxim, May

Ella, Mineral Springs, New Pratt, Nubell, Praco and Togo, Jefferson County, Ala.

American Black Creek Coal Co., (Mount Pinson Coal Co.) Mine at Black Creek, Jefferson County, Ala.

J. D. Ratliff, Irondale, Ala. Mine at Ratliff, Jefferson County, Ala.

Republic Iron & Steel Co., Republic Bldg., Youngstown, Ohio. Mines at Palos, Sayreton, Thompson, Warner Slope No. 1, Warner Slope No. 2, Jefferson County, Ala.

E. P. Rosamond, Birmingham, Ala. Mine at Powell, Jefferson County, Ala.

Eagle Coal Co., Adger, Ala. Mine at Eagle, Jefferson County, Ala.

Sloss-Sheffield Steel & Iron Co., Birmingham, Ala. Mines at Bessie, Blossburg 3 and 4, Brookside, Cardiff, Flat Top, Sayre, Jefferson County, Ala.

Southern Clay Mfg. Co., Chattanooga, Tenn. Mine at Coaldale, Jefferson County, Ala.

South Pratt Coal Co., Brown-Marx Bldg., Birmingham, Ala. Mine at East Blossburg, Jefferson County, Ala.

Tennessee Coal, Iron & Railroad Co., Birmingham, Ala. Mines at Bay View, Blossburg, Blue Creek No. 4, Docena, Edgewater, Wylam No. 6, Jefferson County, Ala.

Turkey Creek Coal Co., Morris, Ala. Mine at Turkey Creek, Jefferson County, Ala.

Warrior Pratt Coal Co., Birmingham, Ala. Mine at Porter, Jefferson County, Ala.

Warrior Timber & Contracting Co., Birmingham, Ala. Mine at Big Sandy, Jefferson County, Ala.

Daniels Creek Coal Co., Birmingham, Ala. Mine at Big Sandy, Jefferson County, Ala.

Woodward Iron Co., Woodward, Ala. Mines at Dolomite No. 1, Mulga, and Short Creek No. 1, Jefferson County, Ala.

Brilliant Coal Co., American Trust Bldg., Birmingham, Ala. Mine at Brilliant, Marion County, Ala.

South Brilliant Coal Co., Cullman, Ala. Mines at Parker and Dulin, Marion County, Ala.

Alabama Fuel & Iron Co., Birmingham, Ala. Mines at Acmar No. 1, Margaret No. 2, New Acton, St. Clair County, Ala.

D. T. Boozer, Coal City, St. Clair County, Ala.

(Baird Coal & Iron Co.), Alex Tyson, Coal City, Ala. Mines at Glenn, Marion, Broken Arrow, St. Clair County, Ala.

Coosa Portland Cement Co., Coal City, Ala. Mine at Vulcan No. 6, St. Clair County, Ala.

Ragland Coal Co., Ragland, Ala. Mine at Ragland, St. Clair County, Ala.

W. S. Lovell, Trustee, Birmingham, Ala. Mine at Vulcan, St. Clair County, Ala.

Alabama Fuel & Iron Co., Birmingham, Ala. Mines at Acton No. 1 and Acton No. 2, Shelby County, Ala.

Brookside-Pratt Mining Co., Birmingham, Ala. Mine at Coalmont, Shelby County, Ala.

Climax Coal Co., Maylene, Ala. Mine at Climax, Shelby County, Ala.

Eureka Coal Co., Birmingham, Ala. Mine at Eureka No. 4, Shelby County, Ala.

Guilliam Coal Co., Birmingham, Ala.

Little Gem Coal Co., Birmingham, Ala. Mine at Dogwood, Shelby County, Ala.

Montevallo Mining Co., American Trust Bldg., Birmingham, Ala. Mine at Aldrich, Shelby County, Ala.

Montevallo-Shelby Coal Co., Straven, Ala. Mine at Straven, Shelby County, Ala.

Southern Coal & Coke Co., Maylene, Ala. Mine at Boothton No. 1, Shelby County, Ala.

West Helena Coal Co., American Trust Bldg., Birmingham, Ala. Mine at Licard, Shelby County, Ala.

Patton Coal Co., Helena, Shelby County, Ala.

Co-operative Mining Co., Birmingham, Ala. Mine at Helena, Shelby County, Ala.

Aetna Coal Co., American Trust Bldg., Birmingham, Ala. Mine at Aetna, Tuscaloosa County, Ala.

The Alabama Co., Birmingham, Ala. Mines at Brookwood and Searles, Tuscaloosa County, Ala.

Big Sandy Iron & Steel Co., Coaling, Ala. Mine at Cedar Grove, Tuscaloosa County, Ala.

Blair Coal Co., Tuscaloosa, Ala. Mine at Blair, Tuscaloosa County, Ala.

Cannon & Shepherd Coal Co., Tuscaloosa, Ala. Mine at Gilmore, Tuscaloosa County, Ala.

Central Iron & Coal Co., Holt, Ala. Mine at Kellerman, Tuscaloosa County, Ala.

Daniels Creek Coal Co., Birmingham, Ala. Mine at Woodrow, Tuscaloosa County, Ala.

Davis Creek Coal & Coke Co., Rock Castle, Ala. Mine at Rock Castle, Tuscaloosa County, Ala.

Liberty Coal Co., Birmingham, Ala. Mine at Liberty, Tuscaloosa County, Ala.

Minnie Coal Co., Birmingham, Ala. (Succeeded by Calhoun Land & Mining Co., Coaling, Tuscaloosa County, Ala.)

Northport Coal Co., Northport, Ala. Mine at Mabel, Tuscaloosa County, Ala.

Shiras Coal Co., Cottondale, Ala. Mine at Alice, Tuscaloosa County, Ala.

Yolande Coal & Coke Co., Birmingham, Ala. Mine at Yolande No. 1, Tuscaloosa County, Ala.

Aaron & Sanford Coal Co., R. R. 1, Parrish, Ala. Mine at Borden, Walker County, Ala.

American Mining Co., America, Ala. Mine at Standard, Walker County, Ala.

Amer. Pratt Coal Co., Parish, Walker County, Ala.

Annie Mae Coal Co., Corona, Ala. Mine at Annie Mae, Walker County, Ala.

Atlas Mining Co., Oakman, Ala. Mine at Atlas, Walker County, Ala.

J. R. Baird Coal Co., Dora, Walker County, Ala.

Barney Coal Co., Cordova, Ala. Mine at Barney, Walker County, Ala.

Bertha Coal Co., Parrish, Ala. Mine at Dixie, Walker County, Ala.

Bell Top Coal Co., Carbon Hill, Ala. Mine at Back Skuttle, Walker County, Ala.

Benoit Coal Mining Co., Jefferson County Bank Bldg., Birmingham, Ala. Mine at Benoit, Walker County, Ala.

Bergens Coal Co., Inc., Red Star, Ala. Mine at No. 1 Bergens, Walker County, Ala.

Black Creek Coal Co., Nauvoo, Ala. Mines at Nauvoo No. 1 and Nauvoo No. 2, Walker County, Ala.

Thomas Bolen, Dora, Ala. Mine at West Pratt No. 7, Walker County, Ala.

Blue Ridge Coal Co., Jasper, Ala. Mine at Big Ridge, Walker County, Ala.

Borden Coal Co., Jasper, Ala. Mine at Glen, Walker County, Ala.

Brilliant Coal Co., Birmingham, Ala. Mine at Calumet, Walker County, Ala.

Brookside Pratt Mining Co., Birmingham, Ala. Mine at Carbon Hill, Walker County, Ala.

Burnwell Coal Mining Co., Burnwell Mines, Ala. Mines at Burnwell and Samoset, Walker County, Ala.

W. M. Bynon, Carbon Hill, Ala. Mines at Bynon, Walker County, Ala.

Caledonia Coal Co., Bankhead, Ala. Mine at Bankhead, Walker County, Ala.

Carbon Hill Water & Light Co., Carbon Hill, Ala. Mine at Carbon Hill, Walker County, Ala.

Central Coal Co., Dora, Ala. Mine at Black Creek, Walker County, Ala.

Chabert Coal Co., Corona, Ala. Mine at West Corona, Walker County, Ala.

City Coal Co., Jasper, Ala. Mine at Wagon No. 4, Walker County, Ala.

S. J. Childers & Son, Jasper, Ala. Mine at Childers, Walker County, Ala.

Cowart Merc. Co., Nauvoo, Ala. Mine at Cowart, Walker County, Ala.

Coal City Coal Co., Jasper Ala. Mine at Johnson, Walker County, Ala.

Commercial Coal Co., Dora, Ala. Mine at Commercial, Walker County, Ala.

Cordova Fuel Co., Birmingham, Alabama. Mine at Cordova Fuel, Walker County, Ala.

Cordova Mineral Co., Cordova, Ala. Mine at Wagon No. 5, Walker County, Ala.

Cordova Warrior Coal Co., Cordova, Ala. Mine at Cordova Warrior, Walker County, Ala.

Corona Coal & Iron Co., Corona, Ala. Mines at Coal Valley No. 10, Coal Valley No. 11, Corona No. 3, No. 7, Patton, Townley No. 1, Townley No. 2, Walker County, Ala.

Corry Coal Mining Co., Oakman, Ala. Mine at Gaslight, Walker County, Ala.

Cryer Coal Mining Co., Cordova, Ala. Mine at Riverside, Walker County, Ala.

DeBardeleben Coal Co., Birmingham, Ala. Mine at Sipsey, Walker County, Ala. and at Paynes Bend, Walker County.

Deer Creek Coal Co., Corona, Ala. Mine at No. 2, Walker County, Ala.

Disney Coal Co., Cordova, Ala. Mine at Red Oak, Walker County, Ala.

Dodd & Son, Nauvoo, Ala. Mine at Wagon No. 7, Walker County, Ala.

Dodd-Clark Coal Co., Carbon Hill, Ala. Mine at Wagon No. 8, Walker County, Ala.

Dora Coal Mining Co., Birmingham, Ala. Mine at Walker County, Ala.

Dora Fuel Co., Dora, Ala. Mine at Walker County, Ala.

Empire Coal Co., American Trust Bldg., Birmingham, Ala. Mine at Empire, Walker County, Ala.

Fowler Coal Co., Fowler, Ala. Mine at Fowler, Walker County, Ala.

Galloway Coal Co., Memphis, Tenn. Mines at Miscellaneous No. 12, Great Elk. Alabama, Miscellaneous No. 17, Miscellaneous No. 11, Miscellaneous No. 15, Walker County, Ala.

Carbon Hill Coal Co., Carbon Hill, Ala. Mine at Jagger Creek, Walker County, Ala.

Willard Coal Co.

Wabash Coal Mining Co., Oakman, Ala. Mine at Gravlee, Walker County, Ala.

Highland Coal Co., Carbon Hill, Ala. Mine at Beard, Walker County, Ala.

Hub Coal Co., Carbon Hill, Ala. Mine at Wagon No. 9, Walker County, Ala.

Indian Head Mills of Ala., Cordova, Ala. Mine at Indian Head, Walker County, Ala.

Jagger Coal Co., Birmingham, Ala. Mine at Jagger, Walker County, Ala.

Dixie Coal Mining Co., Jasper, Ala. Mines at Wabash 1 and 2, Walker County, Ala.

John Henry Coal Co., Jasper, Ala. Mine at Hayes, Walker County, Ala.

L. Jones, Carbon Hill, Ala. Mine at Wagon No. 10, Walker County, Ala.

Little Tommie Coal Co., Oakman, Ala.

W. H. Lockhart, Jasper, Ala. Mine at Wagon No. 11, Walker County, Ala.

Oakman Mining Co., Oakman, Ala. Mine at Oakman, Walker County, Ala.

Orient Coal Mining Co., Dora, Ala.

O'Rear Coal Co., Drifton, Ala. Mine at Drifton, Walker County, Ala.

Palmer Fuel Co., Cordova, Ala. Mine at Wagon No. 14, Walker County, Ala.

Miller Coal Co., Cordova, Ala. Mine at Miller, Walker County, Ala.

Parrish Coal Co., Parrish, Ala. Mine at Gayosa, Walker County, Ala.

Peerless Coal Mining Co., Nauvoo, Ala. Mine at Davis No. 2, Walker County, Ala.

J. A. Perry, Carbon Hill, Ala. Mine at Perry, Walker County, Ala.

Piedmont Coal Co., Birmingham, Ala. Mine at Piedmont, Walker County, Ala.

Pocahontas Coal & Mining Co., Carbon Hill, Ala. Mine at Pocahontas, Walker County, Ala.

Porter Coal Co., Jasper, Ala. Mine at Brooks, Walker County, Ala.

Posey Coal Co., Cordova, Ala. Mine at Miller, Walker County, Ala.

Pratt Consolidated Coal Co., Birmingham, Ala. Mines at Clipper, Colta, Dora No. 10, Gamble, Gamma, Ruby, Victor, Wegra, Walker County, Ala.

Pratt Fuel Co., Birmingham, Ala. Mine at Pratt Fuel, Walker County, Ala.

Railway Fuel Co., Parrish, Ala. Mine at Parrish, Walker County, Ala.

D. M. Robbins, Jasper, Ala. Mine at Robbins, Walker County, Ala.

Royal Coal Corp., Red Star, Ala. Mine at Walker County, Ala.

J. W. Self Coal Co., Carbon Hill, Ala. Mine at Self, Walker County, Ala.

Sharon Coal Co., Inc., Dora, Ala. Mine at Walker County, Ala.

Sipsey Coal Mining Co., R. R. No. 1, Empire, Ala. Mine at Dilworth, Walker County, Ala.

Sorrells Coal Co., Dora, Ala.

Sloss-Sheffield Steel & Iron Co., Birmingham, Ala. Mines at America and Ivy, Walker County, Ala.

Southern Fuel Co., Jasper, Ala. Mine at Norvell, Walker County, Ala.

Stith Coal Co., America, Ala. Mine at Stith, Walker County, Ala.

Sulphur Springs Coal Co., Cordova, Ala. Mine at Sulphur Springs, Walker County, Ala.

Summit Coal Co., Dora, Ala. Mine at Summit, Walker County, Ala.

Sunlight Mining Co., Jasper, Ala. Mine at Sunlight, Walker County, Ala.

Supreme Mining Co., Birmingham, Ala. Mine at Supreme, Walker County, Ala.

Tuscaloosa Mining Co., G. B. Hooper, Operator, Oakman, Ala. Mine at Tuscaloosa, Tuscaloosa County, Ala.

Townley Coal Co., Townley, Walker County, Ala.

West Alabama Coal Co., Jasper, Ala. Mine at Gayosa No. 3, Walker County, Ala.

Hattie Wheeler Coal Co., Jasper, Ala. Mine at Hattie Wheeler, Walker County, Ala.

Winona Coal Co., America, Ala. Mine at No. 1, Walker County, Ala.

Rush Coal Co., Carbon Hill, Ala. Mine at Keystone, Walker County, Ala.

Town Creek Coal Co., Empire, Walker County, Ala.

Crow Excavating Co., Delmar, Winston County, Ala.

Glen Mary Coal Co., Natural Bridge, Ala. Mine at Glen Mary, Winston County, Ala.

Buttahatchee Coal Co., Delmar, Ala. Mine at Mary Etta, Winston County, Ala.

Long Coal Mining Co., Natural Bridge, Ala. Mines at Lily No. 1 and Lily No. 2, Winston County, Ala.

Lynn Coal Mining Co., Lynn, Ala. Mine at Crawford, Winston County, Ala.

Monro-Warrior Coal Co., Nauvoo, Walker County, Ala.

Natural Bridge Fuel Co., Natural Bridge, Ala. Mine at Iceberg, Winston County, Ala.

J. M. Thomason, Natural Bridge, Ala. Mine at Glen Mary, Winston County, Ala.

COKE.

PRODUCTION AND CONSUMPTION.

The production of coke in Alabama in 1880, 1890, 1900 and annually from 1910 to 1918 is shown in the following tables:*

Statistics of the manufacture of coke in Alabama, 1880-1918.

YEAR	Establishments	OVENS		Coal used (short tons)	Yield of coal in coke (per cent)	Coke produced (short tons)	Total value of coke at ovens	Value of coke at ovens, per ton
		Built	Building					
1880	4	316	100	106,283	57.0	60,781	$ 183,063	$3.01
1890	20	4,805	371	1,809,964	59.0	1,072,942	2,589,447	2.41
1900	30	6,529	690	3,582,547	58.9	2,110,837	5,629,423	2.67
1910	43	10,132	340	5,272,322	61.6	3,249,027	9,165,821	2.82
1911	44	10,121	280	4,411,298	62.6	2,761,521	7,593,594	2.75
1912	46	10,208	100	4,585,498	64.9	2,975,489	8,098,412	2.72
1913	46	10,284	20	5,218,323	63.6	3,323,664	9,627,170	2.90
1914	38	9,318	0	4,678,196	65.9	3,084,149	8,408,443	2.73
1915	38	9,318	0	4,695,938	65.4	3,071,811	8,545,555	2.78
1916	—	*9,549	97	6,794,100	57.9	4,298,417	15,019,137	3.45
1917	—	9,660	0	7,638,841	63.9	4,892,583	28,394,272	5.80
1918	—	9,433	324	6,827,826	64.0	4,352,172	30,813,378	7.03

*Includes 300 Semet-Solvay, 487 Koppers, and 60 Wilputte ovens.

Comparison of the production and value of coke in Alabama in 1917 and 1918.

YEAR	Number of ovens	Coal charged (short tons)	Coke produced (short tons)	Total value of coke at ovens	Percentage of total U. S. value
1917	9,660	7,638,841	4,892,589	$28,394,272	8.8
1918	9,433	6,827,826	4,352,172	30,813,378	7.8
Increase or decrease	— 227	— 811,015	— 440,407	+2,419,106	
Percentage	— 2.8	— 10.6	— 9.0	+ 8.5	

†All the coke produced in Alabama is made from Alabama coal.

Coke produced in beehive and by-product coke ovens in Alabama, 1916-1918

BEE-HIVE COKE					BY-PRODUCT COKE					TOTAL			
Active ovens.	Coal used (net tons)	Average yield (per cent).	Coke produced (net tons)	Value of coke at ovens.	Active ovens.	Coal used (net tons)	Average yield (per cent).	Coke produced (net tons)	Value of coke at ovens.	Coal used (net tons)	Coke produced (net tons)	Percentage to total U. S. production.	Value of coke at ovens.
1916													
4,269	3,158,417	57.9	1,828,067	$5,828,057	780	3,685,683	67.9	2,470,350	$9,191,082	6,794,100	4,298,417	7.9	$15,019,139
1917													
5,493	3,658,598	58.8	2,151,828	$12,138,161	881	3,980,248	68.9	2,740,761	$16,256,111	7,638,841	4,892,589	8.8	$28,394,272
1918													
5,570	2,949,992	58.2	1,717,721	$12,161,464	807	3,877,634	68.0	2,634,451	$18,651,914	6,827,826	4,352,172	7.8	$30,813,378

Table showing increase or decrease of 1918 over 1917.

YEAR	BEEHIVE COKE				BY-PRODUCT COKE				TOTAL		
	Active ovens	Coal used (net tons)	Coke produced (net tons)	Value of coke at ovens —in dollars	Active ovens	Coal used (net tons)	Coke produced (net tons)	Value of coke at ovens —in dollars	Coal used (net tons)	Coke produced (net tons)	Value of coke at ovens —in dollars
1917	5,493	3,658,598	2,151,828	12,138,161	831	3,980,243	2,740,761	16,256,111	7,638,841	4,892,589	28,394,272
1918	5,570	2,950,192	1,717,721	12,161,464	807	3,877,634	2,634,451	18,651,914	6,827,826	4,352,172	30,813,378
Increase or decrease	+ 77	— 708,406	— 434,107	+ 23,303	— 24	— 102,609	— 106,310	+ 2,395,803	— 811,015	— 540,417	+1,419,106
Percentage	+ 1.4	— 19.4	— 20.2	+ .19	— 2.9	— 2.6	— 3.9	+ 14.7	— 10.6	— 11.05	+ 5.0

VALUE.

Quantity (net tons) and value of coke produced in Alabama, 1913-1918.

	1913	1914	1915	1916	1917	1918	Increase or Decrease	Total Percentage
Quan.	3,323,664	3,084,149	3,071,811	4,298,417	4,892,589	4,352,172	— 440,407	— 9.
Value	$9,627,170	$8,408,443	$8,545,555	$15,019,189	$28,394,272	$30,813,378	—$2,419,106	+8.5

Average value, per short ton and percentage of coke from coal, in Alabama, 1912-1918.

	1912	1913	1914	1915	1916	1917	1918
Average value	$2.72	$2.90	$2.73	$2.78	$3.49	$5.80	$7.08
Percentage yield	64.9	63.6	65.9	65.4	63.3	63.9	64.00

Quantity and value of coal used in the manufacture of coke in Alabama in 1917 and 1918, and quantity and value of same per ton of coke.

YEAR	Coal used (short tons)	Total value of coal	Value of coal per ton	Quantity of coal per ton of coke (short tons)	Value of coal to a ton of coke
1917	7,638,841	$18,776,218	$2.46	1,561	$3,840
1918	6,827,826	18,280,295	2.67	1,274	3,125

COKE OVENS.

Coke ovens in Alabama, 1917 and 1918.

YEAR	Active		Idle		Total		Abandoned	
	Beehive	By-product	Beehive	By-product	Beehive	By-product	Beehive	By-product
1917	5,493	831	3,320	16	8,813	847	1	
1918	5,570	807	3,016	40	8,586	847	278	

Coke ovens in Alabama at the end of 1912-1918

YEAR	Beehive	By-product
1912	9,588	620
1913	9,584	700
1914	8,568	750
1915	8,568	750
1916	8,806	743
1917	8,813	847
1918	8,586	847

Record of by-product ovens in Alabama, 1910-1918.

YEAR	Built	Building
December 31, 1910	280	340
December 31, 1911	340	280
December 31, 1912	620	100
December 31, 1913	700	20
December 31, 1914	750	0
December 31, 1915	750	0
December 31, 1916	743	97
December 31, 1917	847	0
December 31, 1918	847	324

PRICES OF COKE.

Spot prices of Alabama coke ranged from $3.34 in the first part of 1913 and a maximum of $3.45 for the years 1913-1915 in September, 1914, to a minimum of $2.57 in March, 1914. The minimum spot price in 1915 was $2.65 in July, from which the price rose steadily to $3.49 in September, 1916.

The market price for Alabama coke rose rapidly from November, 1917, to a maximum of $8.27 in August and September, 1917.

Substantial increases in the prices of coke allowed by the Fuel Administrator in the Black Creek, Brookwood, and Blue Creek districts on January 29, 1918, and in other portions of the field on February 15, raised the general average in February from $6.06 to $6.92.

Subsequent changes in prices of Alabama coke allowed by the Fuel Administrator raised the general average by the end of 1918 to $7.46.

CHARACTER OF COAL USED.

Of the total amount of coal used in the manufacture of coke in Alabama 93.7 per cent was washed before that it was charged to the ovens. In 1918 out of 6,827,626 tons of coal made into coke 6,396,182 tons were washed. Of the washed coal used 191,772 tons were slack, and 4,478,461 tons were mine run.

There were 431,444 tons of mine run coal unwashed, while there was none of the slack unwashed.

The character of the coal used in the manufacture of coke in Alabama in 1890, 1900 and for the last nine years is shown in the following tables.

Character of coal used in the manufacture of coke in Alabama, 1890-1918, in short tons.

YEAR	Run of Mine		Slack		Total
	Unwashed	Washed	Unwashed	Washed	
1890	1,480,669	0	206,106	123,189	1,809,964
1900	1,729,882	152,077	165,418	1,535,170	3,582,547
1910	771,931	1,308,085	0	3,192,306	5,272,822
1911	693,135	1,295,109	2,937	2,420,117	4,411,298
1912	747,305	896,421	18,793	2,922,979	4,585,498
1913	868,659	684,223	0	3,665,441	5,218,323
1914	703,241	2,069,638	0	1,905,317	4,678,196
1915	158,480	1,522,149	47,061	2,968,248	4,695,938
1916	238,849	2,352,907	0	4,202,344	6,794,100
1917	445,695	4,228,357	0	2,964,789	7,638,841
1918	431,444	4,478,461	0	1,917,721	6,827,626

DISTRIBUTION.

Beehive coke shipped by originating railroads and waterways in Alabama in 1918.

RAILROAD	Shipments (net tons)	Production (net tons)	Percent. of production
Louisville & Nashville	448,756		
Southern	475,108		
Birmingham Southern: Ala. and Georgia	183,565		
Frisco	75,924		
Total	1,172,326	1,717,721	68.5

For the consumption of Coke, and the by-products obtained from the manufacture of Coke for the year of 1916, see Bulletin No. 21 of the Geological Survey of Alabama.

RANK OF STATES IN COKE PRODUCTION.

In 1918 coke was produced in 23 states, and in 4 states only beehive coke was produced. In the other states all the coke produced was the product of by-product, or by-product and beehive ovens combined.

Pennsylvania heads the list in the production of coke with Ohio, Alabama, Indiana, West Virginia, and Illinois following in order. The first five states producing the most coke from by-product ovens rank in the following order, Ohio, Pennsylvania, Indiana, Alabama, and Illinois, while West Virginia is 9 in rank.

The rank of the coke producing states in respect to the total, and of the by-product output for the years 1914 to 1918 inclusive is shown in the following table.

Rank of the States in the production of coke, 1914-1918.

STATE	1914		1915		1916		1917		1918	
	Total	By-product	Total	By-product	Total	By-product	Total	By-product	Total	By-product
Pennsylvania	1	1	1	1	1	1	1	1	1	2
Alabama	2	3	2	3	2	3	2	4	3	4
Ohio	11	9	7	7	6	5	3	2	2	1
Indiana	3	2	3	2	3	2	4	3	4	3
West Virginia	5	14	5	13	4	15	5	12	5	9
Illinois	4	4	4	4	5	4	6	5	6	5
Virginia	6	———	10	———	7	———	7	———	7	———
Colorado	7	———	9	———	8	———	8	———	———	———
New York	12	8	8	6	11	7	9	6	8	6
Wisconsin	8	5	11	8	12	8	10	7	———	———
Michigan	9	6	6	5	10	6	11	8	———	———
Kentucky	13	11	12	12	9	12	12	10	9	11
Massachusetts	10	7	13	9	13	9	13	9	13	10
New Mexico	14	———	14	———	14	———	14	———	12	———
Maryland	19	13	16	10	15	10	15	11	14	12
Minnesota	18	12	21	15	16	11	16	13	10	7
New Jersey	17	10	17	11	20	14	17	14	11	8
Tennessee	16	———	18	17	18	16	18	16	15	13
Utah	15	———	15	———	17	———	19	———	———	———
Missouri	———	———	20	14	19	13	20	15	———	———
Washington	20	15	19	16	21	17	21	17	16	14
Georgia	21	———	22	———	22	———	22	———	18	———

BEEHIVE COKE PRODUCERS IN 1918.

The Alabama Co., Birmingham, Ala. Works at Lewisburg, Jefferson County, and Brookwood and Searles, Tuscaloosa County.

Brookside-Pratt Mining Co., Birmingham, Ala. Works at Murray (Adamsville), Jefferson County.

Birmingham Trussville Iron Co., Birmingham, Ala. Works at Trussville, Jefferson County, Ala.

Gulf States Steel Co., Birmingham, Ala. Works at Sayre, Jefferson County, Ala.

Imperial Coal & Coke Co., Birmingham, Ala. Works at Bradford, Jefferson County, Ala.

New Castle Coal Co., New Castle, Ala. Works at New Castle, Jefferson County, Ala.

Republic Iron & Steel Co., Republic Bldg., Youngstown, Ohio. Works at Thomas and Warner, Jefferson County, Ala.

Sloss-Sheffield Steel & Iron Co., Birmingham, Ala. Works at Birmingham, Blossburg and West Blossburg, Brookside and New Found, Coalburg, Flat Top and Sayre, Jefferson County, Ala., and Ivy, Walker County, Ala.

Tennessee Coal, Iron & R. R. Co., Birmingham, Ala. Works at Bessemer, Blue Creek and Wylam, Jefferson County, Ala.

U. S. Cast Iron Pipe & Foundry Co., Bessemer, Ala. Works at Bessemer, Jefferson County, Ala.

Woodward Iron Co., Woodward, Ala. Works at Woodward, Jefferson County, Ala.

Alexander Tison, Talladega, Ala. Works at Talladega, Talladega County, Ala.

Yolande Coal & Coke Co., Birmingham, Ala. Works at Yolande and New Connellsville, Tuscaloosa County, Ala.

Empire Coal Co., Birmingham, Ala. Works at Empire, Walker County, Ala.

Pratt Consolidated Coal Co., Birmingham, Alabama. Works at Dora, Walker County, Ala.

BY-PRODUCT COKE PRODUCERS IN 1918.

Gulf States Steel Co., Brown-Marx Bldg., Birmingham, Ala. Works at Alabama City, Etowah County, Ala.

Semet Solvay Co., Syracuse, N. Y. Works at Ensley, Jefferson County and Tuscaloosa, Tuscaloosa County, Ala.

Tennessee Coal, Iron & R. R. Co., Birmingham, Ala. Works at Fairfield, Jefferson County, Ala.

Woodward Iron Co., Woodward, Ala. Works at Woodward, Jefferson County, Ala.

FULLERS EARTH.

A SMALL quantity of Fullers earth was produced in DeKalb County. Alabama's production was small and of little importance, but the state ranked sixth among the producing states for the year of 1918. Fullers earth is used chiefly in the refining of petroleum, and the increased production of petroleum caused a large increase in the production of Fullers earth in all producing states. There were less than three producers in the state so no statistics of the 1918 production can be given.

FULLERS EARTH PRODUCERS IN 1918.

Ladd Fullers Earth Co., Fort Payne, Ala. Mine near Fort Payne, DeKalb County, Ala.

GRAPHITE.

By Henry G. Ferguson

INTRODUCTION.

THE peculiar physical properties of graphite—infusibility, chemical inertness, high conductivity, extreme softness, and low specific gravity—fit it for many uses, such as the manufacture of crucibles and other refractory products, lubricants, lead pencils, paint, foundry facings, as a preparation to loosen boiler scale, as polish for gunpowder, and for various applications in electrical works.

Natural graphite may be either crystalline or amorphous. The term crystalline or flake graphite is commonly understood to mean graphite in crystals large enough to be visible to the naked eye; much of the so-called amorphous graphite shows a crystalline structure under the microscope. Crystalline graphite occurs either in veins, as in the Ceylon deposits, or as flakes disseminated through the country rock, as in most of the crystalline graphite deposits of the United States. Most deposits of amorphous graphite are the result of the alteration of coal beds by the intrusion of igneous rocks. Amorphous graphite is also made artificially by means of the electric furnace.

USES OF GRAPHITE.

By far the most important use of graphite is in the manufacture of crucibles, and for this reason graphite is a mineral resource of vital importance in time of war, and American producers of flake graphite have greatly increased their output. The makers of crucibles have also greatly increased their production during the last two years. Graphite for making crucibles must be of great purity. Its content of graphitic carbon should exceed 85 per cent and should preferably be as high as 90 per cent, and it must be practically free from mica, pyrite, and iron oxide. A small amount of quartz is not injurious. Graphite for making crucibles should also be coarse enough for the interlocking fragments to be easily bound together by the clay with which it is mixed. It should preferably contain a large proportion of flakes about 1 millimeter in diameter and should all remain on a 100-mesh sieve.

Most makers of crucibles prefer to use Ceylon graphite mixed with 10 to 25 per cent American flake in part because the more nearly cubical fragments of Ceylon graphite have a much smaller surface area in proportion to their volume than the thin flakes of the domestic graphite and hence require proportionately less clay as a binder. Ceylon graphite is also more nearly free from undesirable impurities such as mica and pyrite. It is possible, however, to use domestic flake graphite alone with good success in crucible manufacture. In recent commercial tests of crucibles made with Alabama flake graphite and domestic clay three No. 80 crucibles, tested in copper melting, gave 21 heats each, and a fourth 42 heats. There is, however, no immediate prospect of a sufficiently increased domestic production to supply the needs of crucible manufacturers, and graphite must still be imported from Ceylon or Madagascar, but it is believed that the percentage of domestic material used could be increased. The only American graphite resembling the Ceylon material is produced in small amount in Montana.

The difficulties encountered since 1914 in finding satisfactory supplies of clay have now been largely overcome, and the crucibles made with domestic clays are of much better grade than formerly. A part of the great demand for crucibles has been due to the fact that crucibles made with domestic clays did not stand as many heats as those made with the Bavarian clay and consequently a larger number were required to accomplish the same work. According to McNaughton,* the results attained in the early attempts to use domestic clays were very unsatisfactory. In certain tests only 4 or 5 heats were secured with crucibles of average size, as against 25 to 30 heats before the war. At present from 15 to 25 heats is the range of average service. The cost of the domestic clay, however, is more than double that of the German clay used prior to the war.

Graphite for other uses does not require the same grade of material as for crucibles, and for most purposes amorphous graphite can be used with as good effect as the crystalline variety. Graphite for foundry facings, commonly known as "silver lead," is of varying degrees of purity, according to the work required. Ceylon dust was formerly used to a considerable extent for this work, but the present high prices, due to the high freight rates, have greatly decreased its use. Next to crucibles, foundry facings probably absorb more graphite than any other single use.

Lubricating graphite must be of a high degree of purity and absolutely free from gritty substances, such as quartz. As size of grain is not essential, either amorphous or crystalline graphite may be used.

For pencils either amorphous graphite alone or a blend of amorphous and fine-grained crystalline graphite is employed. The graphite is mixed with clay in varying proportions, according to the hardness desired. In order that the product shall be uniform, very pure graphite is required.

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*McNaughton, M., The crucible situation: Metal Industry, vol. 15, pp. 431–432, 1917.

For other uses, such as fillers for dry batteries, facings for molds, polish for explosives, paints, boiler mixture, and many similar requirements, either crystalline or amorphous graphite may be used, and the degree of purity essential varies according to the nature of the use.

IMPORTS.

The following table shows the imports of graphite into this country since 1913. As the war has disarranged the usual trade routes and as the statistics of the Bureau of Foreign and Domestic Commerce necessarily show only the country from which the shipments were made, it is necessary to draw some inferences as to the country of origin. Graphite entered in the import statistics as coming from France is probably all of Madagascar origin, and all graphite imported from Great Britain has been assigned to Ceylon, although it may include a small quantity of Madagascar graphite. Similarly, shipments from Japanese ports are assumed to represent Chosen graphite, as the production of graphite in Japan is small. The imports from Canada in 1914 and 1915 were in excess of the Canadian production for these years, so it is possible that these imports include reexported material.

Imports of doubtful origin are placed under "Other countries." Under this heading is included a small quantity from the Dutch East Indies, which is reported to have been crystalline graphite originating in Chosen.

Graphite imported into United States 1913-1918.

COUNTRY OF ORIGIN	Quantity (short tons)						Value					
	1913	1914	1915	1916	1917	1918	1913	1914	1915	1916	1917	1918
Ceylon	16,996	8,882	14,491	26,232	24,575	9,029	$1,674,764	$ 972,408	$1,826,238	$6,356,582	$7,179,208	$2,397,735
Madagascar	—	349	1,468	1,631	4,393	970	—	38,704	184,067	241,868	1,057,081	265,338
Canada	1,662	1,806	2,995	4,127	3,476	3,084	98,665	92,536	116,407	314,177	349,034	236,226
Brazil	—	—	—	1	18	45	—	—	—	75	4,380	7,351
Mexico	4,435	4,259	1,680	5,331	7,570	5,600	198,000	190,075	75,000	238,000	285,568	134,183
Chosen (Korea)	4,170	6,327	2,373	5,375	2,462	568	58,199	96,433	35,292	103,619	83,558	24,455
Italy	236	254	27	151	115	17	4,061	3,203	994	4,133	3,092	628
Austria	660	78	—	—	—	—	9,957	1,258	—	—	—	—
Germany	90	—	—	—	—	—	4,034	—	—	—	—	—
Other countries	630	47	41	169	—	185	62,111	3,644	3,165	21,434	67	26,559
Grand total	28,879	22,002	23,075	43,017	42,609	19,498	2,109,791	1,398,261	2,241,163	7,279,888	8,961,988	3,092,475

*Compiled from reports of department of commerce.

DOMESTIC PRODUCTION.

CRYSTALLINE GRAPHITE.

The sales of domestic crystalline graphite in 1918 were larger than ever before. The necessity for conserving shipping made it desirable that imports should be reduced as far as practicable, and the domestic in dustry responded well to the demand made upon it.

Domestic crystalline graphite in the United States, 1916-1918.

	1916		1917		1918	
	Quantity (pounds)	Value	Quantity (pounds)	Value	Quantity (pounds)	Value
Alabama	5,226,940	$492,407	6,223,095	$719,575	7,795,475	$999,152
New York	*	*	2,941,040	261,548	3,266,518	273,188
Pennsylvania	1,095,716	103,377	804,945	77,475	1,016,900	112,059
Other states†	4,609,333	318,964	615,000	35,800	782,946	70,400
	10,931,989	914,748	10,584,080	1,094,398	12,861,839	1,454,799

*Included in "Other states."

†1916: California, Montana, New York, Texas; 1917: Alaska, California, Montana, Texas; 1918: California, Montana, Texas.

Total shipments of crystalline graphite in 1918, including both flake and dust, amounted to 12,861,839 pounds, valued at $1,454,799. As mine stocks were approximately the same at the beginning and end of the year, this represents about the mine production. The sales show an increase of 22 per cent by weight and 33 per cent by value over those for 1917.

Estimates furnished by the producers of crystalline graphite show that out of the total sales of 12,861,839 pounds, 9,811,046 pounds, valued at $1,364,600, or 76 per cent by weight and 94 per cent by value of the total, was flake graphite for the most part suitable for crucible use. The remainder, 3,050,793 pounds, valued at $90,199, was dust or low-grade flake, probably averaging less than 50 per cent of graphitic carbon. The proportion of flake produced was higher than in previous years, owing in part to improved milling methods, whereby a larger proportion of the graphite was saved as flake, and in part to the fact that high freight rates and lack of demand made it unprofitable in many places to attempt to save the lower-grade graphite of the ore.

As usual, the greater part of domestic crystalline graphite was produced in Alabama, New York, and Pennsylvania. The product in these States was all of the variety known in the trade as flake graphite, which occurs as small flakes forming 3 to 10 per cent, by weight, of crystalline schists. In addition, crystalline graphite, resembling in a general way the Ceylon graphite, was produced in Montana, and a small quantity of flake graphite was mined in California and Texas. The number of mines reporting sales of crystalline graphite was 26 in Alabama, 1 in California, 1 in Montana, 3 in New York, 6 in Pennsylvania, and 2 in Texas.

In the first few months of 1918 the domestic industry was in a very difficult situation. The selective draft and the great increase of wages in other industries had caused an acute shortage of labor, particularly in Alabama, and the exceptionally severe winter had also curtailed production greatly. Difficulty in obtaining fuel was also a serious factor in some places. The principal difficulty, however, was the freight embargo made necessary by the congestion of railroad traffic. The mines were able to make only small shipments under special license, and even those manufacturers who had been using domestic graphite were of necessity compelled to accumulate large stocks of imported material. Graphite was placed in classification "G" of commodities excepted from embargo on February 11, 1918, and the situation improved somewhat, although the accumulated foreign stocks made the demand rather slack, and the continued shortage of labor increased the difficulty of production. Shipments of domestic flake during the first quarter of 1918 were less than 250 tons per month.

It soon became evident that the necessity for conserving shipping would require a restriction of imports. The

War Trade Board, therefore, on March 23, 1918, prohibited imports of graphite by sea after April 15 until July 1 and authorized the importation of 5,000 long tons for the remainder of the year. These restrictions did not apply to graphite from Canada and Mexico. By a subsequent ruling nearly 1,000 long tons was licensed for import before July 1 and 1,200 tons for shipment from overseas ports during the last six months of the year. As it appeared that the stocks of imported graphite were sufficient to last the remainder of the year, a ruling was issued on July 2 prohibiting further imports during 1918. As dealers already had large stocks on hand the response of domestic production was gradual. Shipments of domestic flake for the second quarter of 1918, however, averaged over 300 short tons per month, and in July these shipments exceeded 600 short tons. The War Industries Board on August 10 requested all makers of crucibles to use 20 per cent domestic or Canadian flake in their crucible mixtures for the remainder of the year and 25 per cent during 1919, and stated that future applications for import licenses would be improved only for manufacturers complying with this request. On October 2 the War Trade Board issued a ruling permitting importations of graphite of crucible grade for manufacturers whose application had been approved by the War Industries Board. The requirement of 20 per cent of domestic flake immediately created a considerable demand for domestic flake and shipments from August to November averaged more than 500 short tons per month and would probably have been larger but for the epidemic of influenza. After the signing of the armistice the demand naturally fell off sharply, and domestic shipments were only about 240 tons per month during December, 1918, and January, 1919.

The War Trade Board on November 7 announced that the import restrictions were to continue in force until June 30, 1919, but on January 16, 1919, reversed this decision and removed all restrictions. The domestic producers, therefore, face competition from Madagascar and Ceylon, where large stocks have accumulated. At the same time the demand for graphite of crucible grade has fallen to a fraction of its war-time figure, and there seems no hope for any immediate increase in consumption for use in crucibles. The stock of flake graphite, exclusive of dust, on hand at the mines January 1, 1919, was approximately 1,000 short tons.

AMORPHOUS GRAPHITE.

The sales of domestic amorphous graphite during 1918 amounted to 6,560 short tons, valued at $69,455, as compared with 8,301 tons valued at $73,481, in 1917, and 2,622 tons, valued at $20,723, in 1916. The increased use of graphite in foundry facings has absorbed the increased output in this country as well as much imported amorphous graphite, chiefly from Mexico. The dust obtained as a by-product in the concentration of flake graphite and the artificial amorphous graphite produced in the electric furnace are competitors of the natural product. Sales of amorphous graphite were reported from four mines in 1918, as against six in 1917. The producing states were Colorado, Nevada, and Rhode Island. On account of the small number of producers, figures showing the production by States can not be published without disclosing individual returns.

MANUFACTURED AND SECONDARY GRAPHITE.

Graphite is manufactured chiefly by the Acheson Graphite Co., which utilizes electric power generated at Niagara Falls. The output has increased greatly in recent years and now forms an important element in the country's supply of graphite. The bulk graphite is made either from anthracite or from petroleum coke and is utilized mainly in lubricants but also for paints, foundry facings, boiler-scale preventives, and battery fillers. A high degree of purity is claimed for the lubricating graphite manufactured in this manner.

Artificial graphite may be used for any purpose to which natural graphite is put except in the manufacture of large crucibles. Recently, however, patents have been granted for methods of manufacturing crucibles in which artificial graphite may be employed. Under one method a mixture of either natural, flake, Ceylon, or artificial graphite, fused bauxite (aloxite, alundum), and clay is used. The second method is similar except that zirconia is used instead of fused bauxite.

Besides the graphite products in which artificial graphite enters into competition with natural graphite, there are a large number for which artificial graphite is particularly adapted. Chief among these are graphite electrodes, which are not made from natural graphite and the demand for which has greatly increased during recent years.

The figures given below represent only the manufactured graphite that comes into competition with natural graphite.

Graphite manufactured by the Acheson Graphite Co., 1915-1918.

	Pounds
1915	5,084,000
1916	8,397,281
1917	10,474,649
1918	9,182,272

Some work has recently been done on the commercial recovery of graphite from "kish." G. D. Dub, of the Bureau of Mines, recently visited a mill where "kish" graphite was being concentrated, and the following notes are quoted from his report.*

> The product known as "kish" is a mixture of graphite, slag, iron oxide, fragments of iron, and other materials that accumulate about a pig-iron casting ladle or a Bessemer or open-hearth furnace. The graphite is formed during cooling by the crystallization of excess carbon from molten pig iron. The "kish" obtained for refining has contained 8 to 10 per cent of graphite carbon in the form of a light, thin, and fluffy flake.
>
> The method of concentrating and refining "kish" is similar in many ways to the methods employed with natural graphite. The chief points of difference are that "kish" is not subjected to crushing, but is carefully screened and treated with magnetic separators.
>
> "Kish" as a possible source of graphite should not be overlooked. At the present time, however, it is questionable whether enough of this material can be obtained to interfere or compete seriously with the mining of natural flake graphite.

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*Dub, G. D., Bureau of Mines, War Min. Inv. Ser. 3 p. 17, 1918.

Samples of the finished graphite received by the Geological Survey show a very clean, though light and thin flake, which should be excellent for lubrication.

A small quantity of high-grade graphite has been recovered from old crucibles by Harry Schmehl, of Chester Springs, Pa. The crucibles are crushed in a small mill and the graphite is recovered by oil flotation. Old graphite crucibles are also crushed and used in the manufacture of foundry facings but without separating the graphite from the matrix.

PRICES.

Domestic flake graphite brought slightly lower prices for the best grades and rather higher prices for the lower grades in 1918 than in 1917; the average price on all crystalline graphite sold was higher owing to the greater proportion of high-grade material. The average prices received at the mines for all grades ranged from 10 to 17¾ cents a pound for No. 1 flake; from 7 to 13 cents a pound for Nos. 2 and 3; and from 1 to 1.8 cents a pound for dust. Flake graphite containing about 90 per cent of graphitic carbon sold for prices ranging from 15 to more than 18 cents a pound, and the graphite containing 85 per cent of graphitic carbon, which formed the bulk of the output, sold at 10 to 15½ cents—probably the greater part at 14 to 15 cents a pound. A small quantity of No. 1 flake with a content of graphitic carbon lower than 85 per cent brought prices ranging from 8 to 11 cents. During October some sales of Alabama graphite were made on a basis of 15½ cents a pound for material containing 85 per cent of graphitic carbon, with an allowance of 1 cent a pound for each per cent of graphitic carbon above that figure.

In general prices were lower during the early part of the year than in the summer and reached their maximum in September and October. Since the armistice there has been very little demand. Alabama graphite was quoted early in 1919 at 9 to 12 cents a pound, according to grade, but some sales have been made at higher figures.

The average prices received at the mines for No. 1 flake have been as follows: 1911 to 1914, 6 to 8 cents a pound; 1915, 7 to 10 cents; 1916, 10 to 16 cents; 1917, 12 to 18 cents; 1918, 10 to 17¾ cents.

Ceylon graphite of the better grades is more largely used by crucible makers than domestic flake graphite and commands a higher price. During the war the tremendous increase in manufacture of crucibles caused a demand for the Ceylon product much in excess of the available supply, and the price increased greatly over pre-war figures. The following table showing prices of Ceylon graphite c. i. f. New York for the years 1914-1918, is based on information furnished to the War Trade Board by importers.

The following table shows the average prices of Ceylon and Madagascar graphite imported into this country, as compiled from the records of the Bureau of Foreign and Domestic Commerce, and the average prices of all grades of domestic crystalline graphite, including both dust and flake, as reported by the producers. The sharp increase in the price of Ceylon graphite in 1916 appears to be due to the diminished import of lower-grade material as well as to enhanced prices for the better grade

Average price of crystalline graphite, in cents a pound, 1913-1918.

	Ceylon	Madagascar	Domestic		Ceylon	Madagascar	Domestic
1913	4.9	....	5.0	1916	12.0	7.4	8.4
1914	5.5	5.5	5.5	1917	14.6	12.3	10.3
1915	6.3	6.3	5.9	1918	11.9	13.6	11.3

It is believed that most of the purchases of Ceylon lump during 1918 were made at prices ranging from 21 to 24 cents a pound; chip, 15 to 20 cents a pound; and dust, 6 to 12 cents a pound. The customs figures give an average declared valuation of 13.3 cents a pound at the port of shipment for all Ceylon graphite imported in 1918.

In 1918 Madagascar graphite entered the market in quantity only during the first four months. Sales to consumers were made at 15 to 18 cents a pound for crucible flake. Had import licenses been freely granted, prices would hardly have exceeded 12 cents a pound.

Prices for Canadian graphite averaged about the same as for similar grades of domestic graphite. Reports from consumers give 9 to 16 2-3 cents a pound as prices paid for flake and three-fourths of a cent to 3¼ cents for dust. The customs figures give an average declared valuation of 3.8 cents a pound for graphite imported from Canada in 1918.

Domestic amorphous graphite brought widely varying prices, according to the grade of the material mined. Although the demand was generally good, the prices do not appear to have increased greatly during the year. The average price for sales at the mines was $10.59 a ton and the range in price was from $5 to $20 a ton. Most of the amorphous graphite on the market was of Mexican origin. This sold at widely varying prices according to the grade, from $35 to more than $100 a ton. Very little Chosen graphite was put on the market in 1918, owing to import restrictions. Some sales at $60 a ton were reported.

ALABAMA—GENERAL FEATURES.

As usual, Alabama led in the production of crystalline graphite. The sales for 1918 amounted to 7,795,475 pounds, valued at $999,152, an increase of 25 per cent in quantity and 39 per cent in value over 1917. Sales of flake greatly exceeded those for 1917, but there was little market for dust and many operators made no attempt to save it.

The year 1918 was marked by improvements in milling methods which have to some extent compensated for the tremendous increase in costs. Alabama milling practice has been described in detail in a recent publication of the Bureau of Mines. At present the average recovery from the Alabama ores, which contain about 2½ per cent of graphite, is about 19 pounds of No. 1 flake, 5 pounds of No. 2 flake, and 3 pounds of dust per ton of ore. Work has been most active in the Ashland district in Clay County. The producing companies number 24 in Clay County, 5 in Coosa County, and 1 in Chilton County. In spite of the great increase in the number of companies only a comparatively small portion of the graphite-bearing area is yet under development, and for the most part the operations are confined to localities near the power lines of the Alabama Power Co.

The Alabama flake graphite from different mines varies greatly in purity, and lack of standardization hinders the full development of the deposits. A few companies produce a No. 1 flake containing 90 per cent carbon, others maintain an 85 per cent standard, and some market flake averaging only about 80 per cent.

The following analyses, furnished through the courtesy of one company, shows the content of the average grade of the Alabama product. No. 1 represents samples from 5 tons and No. 2 from 3 tons of flake.

Analyses of Alabama flake graphite.

	1	2
Volatile matter	2.00	1.08
Carbon (graphitic)	84.00	84.72
Ash	14.00	14.20
	100.00	100.00
Iron	.97	
Sulphur	.08	

Ash analysis of sample 2.

	Ash	Percentage for entire product
Fe_2O_3	8.32	1.18
Al_2O_3	22.94	3.26
SiO_2	64.27	9.13
CaO	Trace	Trace
MgO	1.43	.20
S	.32	.05
Alkalies	2.78	.39
	100.06	14.21

The ash analysis indicates that the principal foreign impurity in the finished product is silica, with a little clayey matter, very little mica, and almost no pyrite.

The graphite occurs in a graphitic schist which forms lenses in a series of metamorphic rocks traversing parts of Clay, Coosa and Chilton counties. Quartz is the principal constituent of the graphite-bearing schist, with subordinate amounts of pyrite, mica (biotite), and apatite. These bands of schist rarely exceed 100 feet in thickness and appear to be fairly continuous, though prospecting has not yet proceeded sufficiently to establish their continuity over long distances. The average graphite content of the ore in terms of graphitic carbon is 3 or 4 per cent, though in some places analyses show a carbon content of 5 or 6 per cent. In nearly every deposit the graphite schist is intruded by small stringers of pegmatitic granite. These contain only a little graphite, but appear to have caused a more intense recrystallization of the original carbon in the intruded rock, which has resulted in a coarsening of the flake in the immediate vicinity and possibly in an actual enrichment in the graphite content. The wall rocks are in most places schists that are similar in type to the graphite-bearing schist but contain less graphite and more mica. At a few localities, however, one wall consists of hornblende schist, probably an altered basic intrusive. No graphite is found where the hornblende schist is intruded by granite—an evidence that the carbon from which the graphite is derived is not a product of the granite intrusion. The graphite schists commonly crop out along ridges, and, as a rule, the overburden is very light. The pyrite of the deposits is in most places completely oxidized to the depth of 50 to 60 feet. Besides removing this very objectionable constituent of the ore, weathering has softened the rock and lessened the coherence between the graphite and the other minerals, which facilitates both mining and concentration. The unoxidized schist is avoided as far as possible in mining operations, as it is hard to crush, and the pyrite can be completely eliminated from it only with difficulty. It would, however, be perfectly feasible to treat this "blue rock" should necessity arise.

The following recent articles are of interest in regard to the graphite deposits of Alabama.

Prouty, W. F., Flake graphite in Alabama; its location, its history, and its value to the State: Birmingham Age-Herald, January 28, 1917.

——— Extent and development of flake graphite resources of Alabama: Manufacturers' Rec., April 19, 1917, pp. 66-67.

Pratt, J. H., Alabama graphite deposits: Manufacturers' Rec., March 22, 1917, p. 58.

Herr, Irving, Clay County graphite district of Alabama: Eng. and Min. Jour., vol. 103, pp. 693-697, April 21, 1917.

MINING AND CONCENTRATION.

Mining is done in open cuts, and in common practice a 30-foot face is broken down with a single charge of dynamite and the material loaded into cars. The large blocks are broken by hand or by small charges of powder. In loading a certain proportion of low-grade material is discarded. The deposits with steep dips are, of course, at an advantage over others in the costs of mining.

Milling methods are much the same in most of the mills and may be described briefly. Large bins have been installed in most of the newer mills to allow steady runs even in wet weather, as it is of great advantage to have the ore as dry as possible. The ore passes to a jaw crusher, where it is broken to about 1-inch size and next to a rotary cylindrical drier. In some mills rolls are used before drying. The dry ore is next crushed in rolls and screened, the oversize going back to the rolls and the fines passing to the water flotation concentrator. In some mills the crushed ore first passes through an air separator in which a suction fan removes the graphite and dust and leaves the coarser sand behind. This process is open to the objection that a certain quantity of coarse flake is left behind with the sands and some fine graphitic dust is inevitably lost. Where a middling product is made it is returned to the rolls. In some of the newer mills the graphitic sands pass from the drier into cooling bins, where they remain 24 hours, the bins being drawn on alternate days. The reason for this is that water flotation has been found to act more effectively on cool material.

The principal concentration process is water flotation. The flotation separator is a rectangular trough 5 to 9 feet long, 6 to 10 inches wide, and 12 to 18 inches deep. This trough is filled with water, which is supplied in a thin curtain from the top along the entire length of one side and overflows into a launder on the other side. The amount of water is regulated so that the flow across the trough shall be as smooth and free from ripples as possible. The graphitic sand is fed in a thin stream onto the moving water surface. In a few mills the sand is fed over a revolving shaft which distributes the feed more evenly. Most of the sand sinks, and the graphite flakes, together with a little mica and fine grit, float off on the moving water. A recent modification of the flotation separator is circular in form and about 6 feet in diameter, and in it the sand is fed at the apex of a stationary or revolving cone.

The launders carry the concentrates to shaking screens, on which they are freed from surplus water. Fine sprays falling on these screens wash out a part of the fine grit. In one mill a hexagonal reel is used instead of the shaking screen. The concentrates are next dried on a concrete drying floor heated by steam or in double-chambered rotary cylindrical driers. In some mills the concentrates then pass through another air separator. This removes whatever coarse grit has been floated with the graphite.

The finishing process consists of grinding in burrstone mills and screening in bolting reels or inclined shaking screens of the kind used in flour mills. The purpose of the burr mill is to break the grains of quartz so that they will pass through the finest screen with the dust while the No. 1 and No. 2 flake remains as oversize from the different screens. In a few mills electrostatic separation has been tried in place of burr mills for the final finishing, but in the Clay County mills it has not proved satisfactory.

Three mills use processes different from that outlined above. The new mill of the Alabama Graphite Co. uses a wet process for the preliminary concentration. The material is crushed in jaw crushers and is then fed with water into the muller and from that to a log washer, in which the sands are screened toward the discharge at the upper end while the graphite flakes float off at the lower end. The dewatering and finishing process is the same as that outlined above. The Ceylon Co. uses an oil-flotation process and the Flaketown Graphite Co. uses a dry process throughout.

The usual Alabama system as outlined above is open to the following objections:

1. The recovery is low; in most mills the total of the finished product amounts to about 2 per cent of the ore handled. As none of the final product is pure graphite, this probably means a total saving of not over 60 per cent of original graphite content.

2. The quantity of dust is too great in proportion to the quantity of No. 1 flake produced. The proportion of different products varies from 40 to 50 per cent of No. 1 flake, 25 to 15 per cent of No. 2 flake, and 40 to 35 per cent of dust. Grinding dry in the muller or Chile mill and the final grinding in the burr mills probably breaks the flake badly.

3. Under the present system the ore must be dried before the graphite can be separated by water flotation and the concentrates must be dried again before finishing. A wet concentration process would eliminate the preliminary drying.

4. There is no uniform standard for No. 1 flake. A few producers guarantee a 90 per cent carbon content but the majority produce No. 1 flake carrying about 85 per cent.

5. The dust-filled mills can not fail to be injurious to the health of the workers.

The organization of the Graphite Association of Alabama (A. B. Conklin, secretary, Ashland, Ala.) has been of great assistance to the industry, as it enables the graphite producers of the State to take united action in matters affecting the mining industry, such as the railroad embargo. The association is preparing to obtain a better standardization of the Alabama flake.

FUTURE OF THE GRAPHITE INDUSTRY.

DOMESTIC.

Even at the present war prices the miners of this country who are working deposits of disseminated flake graphite must depend on their No. 1 and No. 2 flake for their profit. The dust and lower-grade flake produced are merely by-products and are salable only at a very low price. The object of the operators is consequently to produce as large a proportion of flake as possible. The usual process of finishing involves grinding in burr mills in order to break the small particles of quartz and allow them to be separated out by screening. This process necessarily breaks the flake and increases the amount of dust. Developments in graphite milling practice during 1917 give promise of a largely increased production of flake of better grade. Among the new methods is oil flotation, particularly in the Alabama field, where several companies are using it with marked success. If flake graphite holds its present prices, profits can be made by a mill of almost any type, but at the prices that prevailed in time of peace only the most efficiently managed mills can hope to survive. Madagascar's output is increasing rapidly, and after the war domestic producers will have to meet competition from this island as well as from Ceylon. If Madagascar graphite can in normal times be put on the London market at a cost of approximately 4 cents a pound,* the price at New York would not be much higher, and it can readily be seen how formidable a competition will have to be met by the domestic producers when the shipping situation becomes normal again and how essential it is that the methods of mining and milling should be brought to as high a degree of efficiency as possible. The Ceylon graphite is considered by American manufacturers to be better suited to the manufacture of crucibles and will probably continue to command a higher price than the domestic. The costs of mining in Ceylon have advanced considerably in recent years, however, since deep mining has become necessary, and it is probable that unlike Madagascar, which is a new field, Ceylon will not increase her production greatly. Moreover, it is probable that the greater use of the electric furnace in metallurgic operations will somewhat retard the demand for graphite crucibles. The following table shows the notable development in electric-furnace steel during the last few years, while the production of crucible steel has remained about stationary.

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*Shelley, J. W., Graphite in Madagascar: Min. Mag., vol. 14, p. 327, 1916.

Steel ingots and castings, produced in the United States, 1909-1917, by processes, in gross tons.*

	Crucible	Electric
1909	107,355	13,762
1910	122,303	52,141
1911	97,653	29,105
1912	121,517	18,309
1913	121,226	30,180
1914	89,869	24,009
1915	113,782	69,412
1916	129,692	168,918
1917	126,716	304,543

*Am. Iron and Steel Inst. Ann. Rept. for 1916, p. 24, New York, 1917.

Under conditions such as prevailed in the summer of 1917 nearly any grade of flake graphite is salable, and there are no definite standards governing specifications. Consequently, other things being equal, the buyer will prefer the imported graphite, for which there are fairly well recognized standards. It would seem advisable for the domestic producers, now that their product is in good demand, either to adopt standards for different grades of flakes, in order that when imported graphite comes on the market more freely they may be better able to meet the competition, or so to regulate their milling methods that they may be able to prepare special grades based on the purchaser's specifications. It is probably impossible to standardize grades for the whole country, owing to the different methods of treatment necessary for different types of ore, but where conditions are essentially the same over a large area, as in the Alabama field, co-operation among the producers might result in the establishment of two or three standard grades, based on the percentage of graphitic carbon and size of flake, with a guaranteed minimum of silica and iron. This would give the producers a far stronger position in the market and make the crucible manufacturers more ready to use domestic flake.

Graphite for other uses, such as for lubricants, pencils, foundry facings, and paints, will probably continue to be in good demand, but unless the deposits are large and cheaply mined, the prices of the grades required for these uses do not make them profitable to the producer. Here again the expected competition after the war of the graphite dust from Madagascar and Ceylon and amorphous graphite from Mexico and Chosen, as well as artificial amorphous graphite, will be difficult to meet. Better milling methods, resulting in a higher graphite content of the dust produced, will aid the situation greatly. For instance, dust as ordinarily produced at flake graphite mines carried about 40 per cent carbon and is sold at less than 1 cent a pound, but this same dust when refined to a degree of purity suitable for use as a filler for dry batteries commands many times this figure.

Perhaps it may be found feasible to manufacture many graphite products in the vicinity of the mines. In this connection an article by Bartley is worthy of attention.

The large number of new companies beginning operations at the present time naturally makes it of importance to consider the probable effect of the future increased production upon the market. If all the mills in the Alabama field are able to operate at anything like their expected capacity, the result will be an annual production of flake graphite of approximately 30,000,000 pounds, about 15 times the production of Alabama in 1913, and nearly equal to the entire importation from Ceylon for that year. As long as the war continues a largely increased production can probably be absorbed by crucible makers and other users of crystalline graphite, but if the graphite from Ceylon and Madagascar continues to enter the market freely, the price of domestic graphite will necessarily be reduced with the increase in production. On the other hand, mining conditions in Alabama are very favorable, the mining costs are low, and new developments in concentration and finishing will probably result in a larger percentage of good flake in the finished product and a higher saving of graphite of all grades. Costs of mining and milling at an efficiently managed plant should not exceed $50 a ton of concentrates produced, or about 2½ cents a pound for the finished product, and even with prices as low as 5 cents a pound for No. 1 flake, 3 cents for No. 2, and 1½ cents for dust, there should still be a possibility of profit. A recent article by Prouty* contains an interesting discussion of costs of production of graphite in Alabama. It is of course idle to speculate on the possible duration of present conditions, and the situation may be summed up by saying that as long as the present demand for crucibles in the manufacture of munitions continues, the plants in operation should all be able to make profits, and even with the expected drop in prices after the war the most favorably situated and efficiently managed plants should continue to be profitable.

With a return of peace, however, operators will face an unfavorable condition caused by a decreased market and large increase in production.

The following companies either reported sales or stated that they had begun the production of graphite in 1918:

ALABAMA GRAPHITE COMPANES.

Alabama Graphite Co., Ashland, Ala. Mine at Ashland, Ala.
C. B. Allen Graphite Co., Ashland, Ala. Mine at Ashland, Ala.
American Graphite Co., Ashland, Ala. Mine at Ashland, Ala.
Ashland Graphite Co., Ashland, Ala. Mine at Ashland, Ala.
Atlas Graphite Co., Ashland, Ala. Mine at Ashland, Ala.
Axton Noe Graphite Co., Louisville, Ky., Mine at Ashland, Ala.
Carbon Mountain Graphite Co., Lineville, Ala. Mine at Lineville, Ala.
Ceylon Graphite Co., Birmingham, Ala. Mine at Hollins, Ala.
Clay County Graphite Co., Ashland, Ala. Mine at Hollins, Ala.
Crucible Flake Graphite Co., Ashland, Ala. Mine at Hollins, Ala.
Crystalline Flake Graphite Co., Ashland, Ala. Mine at Hollins, Ala.
Diamond Graphite Co., Alexander City, Ala. Mine at Goodwater, Ala.

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*Prouty, W. F., Extent and development of flake graphite resources of Alabama; Manufacturers' Rec., Apr. 19, 1917, pp. 66–67.

Duro-Flake Graphite Co., Montgomery, Ala. Mine at Coosa County, Ala.

Flaketown Graphite Co., Mountain Creek, Ala. Mine at Mountain Creek, Ala.

Goodwater Graphite Co., Goodwater, Ala. Mine at Goodwater, Ala.

Graphite Mills (Inc.), Ashland, Ala. Mine at Ashland, Ala.

Griesemer Graphite Co., Ashland, Ala. Mine at Ashland, Ala.

Hood-Graves Graphite Co., Alexander City, Ala. Mine at Ashland, Ala.

Jefferson Graphite Co., Birmingham, Ala. Mine at Ashland, Ala.

Jennings Graphite Co., Talladega, Ala. Mine at Lineville, Ala.

Liberty Graphite Co., Birmingham, Ala. Mine at Lineville, Ala.

Lineville Graphite Co., Lineville, Ala. Mine at Lineville, Ala.

May Brothers Graphite Co., Ashland, Ala. Mine at Ashland, Ala.

Monitor Graphite Co., Ashland, Ala. Mine at Ashland, Ala.

National Flake Graphite Co., Ashland, Ala. Mine at Ashland, Ala.

Parkdale Graphite Products Co., Hollins, Ala. Mine at Parkdale, Ala.

Peerless Flake Graphite Co., Lineville, Ala. Mine at Lineville, Ala.

Quenelda Graphite Co., Quenelda, Ala. Mine at Quenelda, Ala.

Republic Graphite Co., Ashland, Ala. Mine at Ashland, Ala.

Southern Graphite Co., Ashland, Ala. Mine at Ashland, Ala.

The Quenalda Graphite Corporation has recently absorbed the following graphite plants in the Alabama field: The Quenalda Graphite Co., American Graphite Co., Crucible Flake Graphite Co., Carbon Mountain Graphite Co., Peerless Flake Graphite Co.

IRON ORE.

ERNEST F. BURCHARD.
EUGENE A. SMITH.

ESSENTIAL FEATURES OF AN IRON-ORE DEPOSIT.

THE war in Europe has greatly stimulated prospecting for minerals and ores in the United States, and as a result of this prospecting many specimens are sent to the United States Geological Survey for identification. The majority of specimens are readily identified at sight; some require a brief visual examination; others require more elaborate physical or chemical tests. The Survey is not permitted to make chemical analyses or assays of minerals or ores for private persons or corporations, but it is compatible with the duties of the Survey to inspect a specimen and to state, if possible, what it is; to give an offhand opinion as to whether or not the material constitutes an ore; and to recommend or discourage further expense in prospecting it or in having analyses or assays made.

Iron minerals are among the most common and are abundantly distributed, and naturally many specimens are received by the Geological Survey. It is therefore believed that a few notes on these minerals and on the requirements of a deposit in order to render it of commercial importance may be of interest to those making inquiries on the subject. The classes of iron minerals that constitute a source if iron ore are oxides and carbonates. There are three general varieties of oxides, viz., hematite, brown ore, and magnetite. Brief descriptions of each follow:

SOURCE OF IRON.

The forms in which iron occurs in the earth in combination with other substances are very numerous. Nearly all hard rocks, as well as the softer soils, sands, clays, and many "mineral" waters contain iron in some combination and in varied proportions. Iron is seldom found "native"—that is, occurring in the earth in the form of metallic iron. When it is found in the metallic state, as, for instance, in meteorites that have fallen from space upon the earth, it is not in quantities large enough to be of commercial value. The combination of iron with one or more other substances is called an iron compound, or iron mineral, and where the iron compounds are such that iron can easily be extracted from them and they occur in such abundance that they can be mined profitably these iron compounds are called iron ores.

Iron in combination with other substances is regarded next to aluminum, a metal contained in clay, as the most abundant metal. Thus, according to recent calculations,* metallic iron forms about 4.50 per cent of the rock crust of the earth, compared with 7.85 per cent for aluminum.

IRON ORE.

There are four important types of ores of iron—red iron ore, or hematite; brown ore, or limonite; magnetic ore, or magnetite; and carbonate ore, or siderite—although there are hundreds of minerals in which iron is a constituent. These types of ore may easily be remembered through their most common colors, which are, respectively, red, brown, black and grayish.

Hematite.

Hematite includes all varieties of the anhydrous sesquioxide (Fe^2O^3). This is known locally as red hematite, specular ore, gray ore, fossil ore, oolitic ore, etc. Hematite is composed of two parts of the metal iron united with three parts of oxygen. Iron forms 70 per cent by weight of pure hematite and oxygen 30 per cent, and the mineral is known chemically as the sexquioxide of iron or ferric oxide. Hematite may occur as a rock in beds, in veins, or in masses of irregular shape, and it may occur in a soft, earthy state, or as loose debris in the soil, and yet in all these forms be profitably mined if the controlling conditions are favorable. Hematite is easily recognized in the hand specimen by its colors (red to steel gray and black) and the red mark or streak it leaves when drawn across a rough surface and by its high specific gravity or superior weight as compared with the weight of pieces of ordinary red rock or red clay of equal size. The old-fashioned "keel" or red chalkstone formerly used by carpenters for marking lumber is a form of hematite. Finely ground hematite is used in the manufacture of red paint and other red coloring materials.

Hematite is by far the most important iron ore. It is found in great abundance in the United States in the vicinity of Lake Superior in Minnesota, Michigan, and Wisconsin; in central New York; in the Appalachian region of Alabama, Georgia, Tennessee, and Virginia; and in eastern Wyoming. It also occurs in lesser quantities in Pennsylvania, Maryland, Kentucky, eastern Wisconsin, Utah, and California. (E. F. B.)

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*Clarke, F. W., The data of geochemistry, 3d ed.; U. S. Geol. Survey Bull. 616, p. 34, 1916.

All the ore of this quality mined in Alabama occurs in the Clinton or Red Mountain formation. The Red Mountain ridges occur on each side of the anticlinal valleys which separate the coal fields. In places the red ore ridges are lacking on one side, usually the western, of the valleys, being cut out by faults, while on the other hand the ridge may be duplicated on one side of the valley by the same faults.

In most of the valley occurrences the moderate dips of the ore bed are on the eastern side and there are also practically all of the ore mines. Murphree's Valley makes an exception to this, the moderate dips and the iron mines being on the western side. The iron ore occurs mainly in the central part of the formation in seams or beds one to five in number, which vary in thickness from a few inches to thirty feet.

While the ore seams are very persistent along the outcrop which in Alabama must be as much as 50 miles, yet they vary greatly from place to place, being either too thin or too lean for profitable working in the greater part of this distance.

The most important development of the Clinton ore in this State and in the world is along the 15 or 16 miles stretch of the east Red Mountain between Birmingham and Bessemer, and there is a practically continuous series of mines and strippings for this entire distance. Much mining of this ore has also been done near Gate City, Village Springs, Attalla, Gadsden, Round Mountain, Gaylesville, Fort Payne, Valley Head, etc.

The completion in October, 1912, of a diamond drill boring in Shades Valley, within a mile of the base of Shades Mountain, gives a definite answer to the speculations concerning the occurrence of red ore under Shades Valley. This boring shows that there is no falling off in the thickness and quality of the ore with distance from the outcrop, and that the depth of the ore below the surface at a distance of more than 2½ miles from the outcrop of Red Mountain is not too great for shaft mining.

The importance of this demonstration of a vast increase in the amount of red ore available immediately or in the near future, cannot well be overestimated.

In 1913 the Gulf States Steel Company acquired about 1,500 acres of land upon which the drill hole above mentioned was located. They have since sunk a double track slope to the ore. In time this is likely to be the largest producing mine in the State.

Another drill hole was put down in Shades Valley in 1913, in Section 19, T. 19, R. 3 W., but the record was not available for publication at the present time.

The production of hematite in Alabama in 1918 was 4,985,557 long tons against 5,949,096 long tons in 1917 a decrease of 963,539 tons or 16.2 per cent. The production is 85.6 per cent of the total iron ore production of the state, and 7.25 per cent of the total iron ore produced in the United States.

There was a large increase in the value of ore in 1918, The average price of hematite in 1917 was $1.61; in 1918 $3.12.

Brown Ore.

Brown ore is composed of iron, oxygen, and water, and in a general way might be said to be hematite combined with water. A general formula may be expressed by $mFe^2O^3nH^2O$. Brown ore may contain water in several proportions so that the percentage of iron likewise varies, but the latter ranges generally from 52 to 66 per cent in the pure mineral. Thus brown ore does not contain quite as high a percentage of iron as hematite, and therefore it can not yield so much metal One of the most common brown ore minerals is known as limonite ($2Fe_2O_33H_2O$), and this contains 59.9 per cent of iron, 25.7 per cent of oxygen, and 14.4 per cent of water. Brown ore occurs in a large variety of forms, nearly all of which have in common a characteristically yellowish-brown to chocolate-brown color and yield a brown streak and powder. Exceptionally certain hydrated sesquioxides of iron may appear bright red, and some may show black surfaces; but these exceptional forms are generally to be found closely associated with a mass of ordinary brown ore, and familiarity with the deposits soon dispels any perplexity regarding the nature of the ore on the part of persons mining or handling it. The specific gravity of brown ore is also higher than that of ordinary rock. Brown ore commonly occurs in irregular masses and lumps, and as ore gravel and sand, embedded in banks of clay, sand, and stone gravel. The ore in places lies in layers, but more commonly in irregular pockets, separated by barren clay, sand, and stone gravel. In places the ore takes the form of hollow concretions or "pots" which may contain some loose sand or clay in the interior and also it appears as honeycombed masses ramifying through the inclosing ore-bearing ground.

Limonite is used chiefly as a source of iron, but the brown and yellow forms, called ocher, are used for paint and for making oil-cloth and linoleum. A porous variety of limonite is used in the purification of illuminating gas, and also as a contact material in the production of hydrogen gas for inflation of dirigible balloons and for precipitation of fats from oils. Many iron compounds are used in medicines.

Deposits of brown iron ore are common in many portions of the eastern United States, particularly in valleys underlain by limestone. Some of the best-known deposits are in Connecticut, Vermont, Pennsylvania, Virginia, Tennessee, Alabama, northeastern Texas, and in Iowa and Wisconsin near Mississippi River. (E. F. B.)

This ore though it is second of importance in the state and third in the United States furnishes only 2.3 per cent of the total United States production and 14.4 per cent of the iron ore production of the State in 1918. The total brown ore produced in the United States in 1918 was 1,613,844 long tons, with Alabama holding first place with 769,069 tons or 47.6 per cent of the total United States production.

In the early days of iron making and up to the year 1876 this was the only ore used in the catalan forges, bloomaries, and charcoal furnaces of the State. It was then demonstrated that good iron could be made at low cost from the red ores, with coke for the fuel.

In general the limonites are considered the best of the ores of Alabama, commanding the highest prices and a ready sale.

The usual mode of occurrence is in irregular masses of concretionary origin in the residual clays resulting from the decomposition of limestones, and as a consequence the mining is uncertain and expensive. Limonite also occurs in regularly stratified seams or beds, and then it is the result of the alteration of pyrites or of carbonate ores. Practically all of the brown ore actually mined is that occurring in the residual clays above mentioned. Most of the ore before going to the furnace is washed and screened, and this manipulation, together with the cost of mining, makes it the most expensive of the iron ores, and it is therefore seldom used alone, but is usually mixed with the red ore in proportions determined by the quality of the iron desired. It is used alone in the charcoal furnaces and also in the coke furnaces when a particularly tough pig iron is wanted.

The limonite deposits are very numerous and are distributed over a broad expanse of country and in many places are known to be very extensive. In some of the deposits the ore is in nearly solid mass, in others it is much scattered, and in consequence the amount of foreign material necessary to be removed for every ton of ore produced, varies very much, not only in different ore banks, but also in the different parts of the same bank.

The deposits occur in nearly all the geological formations of the State, but in most of these the ore is either insufficient in quantity or not pure enough to be of much commercial value. The most important of the deposits, in point of extent and value, occur overlying the following formations, viz., the Knox Dolomite and the Weisner Quartzite, the Lauderdale Chert of the Lower Carboniferous, and the Lafayette. Some extensive beds of ore of inferior quality generally occur also in the Tuscaloosa formation of the Cretaceous, and in the upper part of the Lower Carboniferous and in the Metamorphic rocks.

There was a large decrease in the production of brown ore in the state in 1918 as compared with 1917. The production being 1,088,611 long tons in 1917 compared with 769,067 in 1918, a decrease of 319,544 tons or 29.4 per cent. The price per ton of ore averaged $3.08 in 1917 compared with $3.55, an increase of $0.47 per ton in 1918. (E. A. S.)

Magnetite.

Magnetite (Fe_3O_4) is a black ore of iron which is attracted by the magnet. It contains iron and oxygen in the proportion of 3 parts of iron to 4 parts of oxygen, which by weight gives 72.4 per cent of iron and 27.6 per cent of oxygen. Magnetite thus contains the highest percentage of iron of the ores thus far mentioned, and in fact, of all the iron ores. Magnetite usually occurs in granular form and in crystals in veins in comparatively old crystalline rocks, although it may be found in comparatively young volcanic rock.

Magnetite is found in the United States in considerable quantities in the Adirondack region of New York, the Highlands of New Jersey, south Pennsylvania, eastern Wyoming, central Texas, southwestern Utah, and southern and northern California, and in small quantities in northern Michigan and in other states. It is used chiefly for the production of iron, but the less common variety known as lodestone, which is naturally magnetic, is sold at high prices for museum exhibits and for laboratory purposes. Magnetite is found in the form of sand along streams and on the shores of lakes or seas where it has been concentrated by the action of water. In this form it has not proved of much commercial value as an ore of iron. (E. P. B.)

There has been no development of magnetic ore properly speaking, in Alabama. The gray ore of Talladega County which was mined to some extent a few years ago is essentially a hematite though some of it is slightly magnetic. There was no production of this ore in 1918. (E. A. S.)

Siderite.

Siderite, or iron carbonate ($FeCO_3$), is composed of 1 part of iron, 1 part of carbon, and 3 parts of oxygen and thus contains by weight where pure, approximately 48.3 per cent of iron, 10.3 per cent of carbon, and 41.4 per cent of oxygen. Iron carbonate ore where fresh is generally grayish in color, and occurs in nodules and in layers principally in sedimentary rocks that contain coal and lignite. The carbonate rapidly changes to brown ore on exposure to moist air. Siderite is known locally as spathic iron ore, kidney ore, clay ironstone, and black-band ore. Certain of these names are derived from the appearance of the ore in its different forms. For instance, a bed of carbonate ore that is found on the top of a coal bed in eastern Kentucky is striped with fine black carbonaceous bands.

Iron carbonate, in addition to being found in Kentucky, is common in southeastern Ohio, and occurs to a small extent in Pennsylvania, Alabama, Mississippi, and Texas.

IMPURITIES IN IRON ORE.

Consideration should be given to some of the principal impurities that are found in iron ores, first, in order to appreciate why a deposit of ore never yields the full percentage of iron that the predominant iron mineral contains, and, second, in order to show the relation of the ore to the operation of the blast furnace. Deposits of iron ore are generally so closely associated with the rocks which inclose them that they contain either mixed with the deposit or chemically combined within it some of the other rock-forming minerals. Among the most common of these minerals are silica, or sand; lime and magnesia, derived from limestone and dolomite; alumina, a clay mineral; manganese, a metal resembling iron; and small quantities of sulphur and phosphorus. The presence of varying percentages of these and other minerals tends, of course, to reduce the percentage of metallic iron that the deposit will yield when mined, and they must be removed as far as possible in mining and almost completely in the process of making iron. Therefore, it is of the utmost importance that the average chemical composition of a deposit of iron ore be ascertained before an attempt is made to mine it.

The average composition may be termed the "quality" of the deposit. The quality is determined chiefly by two men, the prospector and the chemist. The prospector digs trenches and pits or drills holes in the ore and takes samples of it. The chemist analyzes these samples of ore in his laboratory, and finds the percentages of metallic iron, silica, lime, alumina, manganese, sulphur, phosphorus, water, etc., contained in average samples of the ore. On the quality of the ore depend the quantity of fluxing stone and fuel that must be used in the blast furnace and the kind of iron that can be produced.

RANGE IN COMPOSITION.

Many chemical analyses of commercial grades of these iron ores indicate a range in composition given in the following table:

Range in chemical composition of commercial grades of iron ore.

	Hematite Per cent	Brown ore Per cent	Magnetite Per cent	Carbonate Per cent
Metallic iron	25-65	35-58	48-70	25-48
Silica	2-35	3-28	0.6-20	1-23
Alumina	0.2-9	1.4-12	0.7-4.5	1-5
Lime	Trace to 27	0-0.6	0.5-4.5	0-7
Manganese	Trace to 5	0.16-5	0.07-1.5	0.1-4.7
Sulphur	Trace to 1.5	Trace to 0.5	Trace to 1.2	0.01-1.8
Phosphorus	0.013-1.23	0.04-1	Trace to 1.75	0.043-0.7
Titanium	0-0.9	....	0-1.5	0-0.04
Water	0.3-6	8.8-15	0.25-0.5	0-6.5

Under exceptional conditions ores are mined that contain more or less of the common constituents indicated above, but local conditions may determine whether an ore that falls within the limits shown may be mined. For instance, hematite carrying as little as 20 per cent metallic iron would not be considered of value as an ore unless it contained enough lime to flux the silica and alumina present. Most Southern red hematites contain considerable quantities of lime and are therefore workable where a highly siliceous ore carrying no more metallic iron and little lime would not be available under present conditions of metallurgic practice. At present ores averaging less than 25 per cent of metallic iron are not charged into blast furnaces in any considerable quantities, and ores as lean as this can not be used economically unless they carry more than enough lime to flux them and are used in connection with richer ore. In using limestone as a flux it would probably be more desirable to use a stone carrying 15 to 20 per cent of ferric oxide (10.5 to 14 per cent metallic iron) than one containing only 3 to 5 per cent ferric oxide, on account of the higher iron yield of the former. Nevertheless, the more ferruginous limestone would not commercially be classed as an ore; yet a bed carrying 35.5 per cent oxide (25 per cent metallic iron), although in itself not quite rich enough might be conceded to be an "ore." There are other exceptions to be noted in this table. Some deposits of non-titaniferous magnetite can be so treated by means of crushing and electromagnetic separation that, although they may contain as little as 25 per cent metallic iron, they will yield a high grade concentrate. Such ores may be used to advantage, especially where they can be concentrated along with richer grades. Considerable phosphorus is present in the mineral apatite associated with Adirondack magnetite; and this and silica are largely eliminated by electromagnetic concentration. The possibilities of various methods of concentration or beneficiation must therefore be taken into consideration in appraising an ore, and this involves consideration of the physical as well as the chemical character of the ore. The content of water is a widely variable item. Some ores contain much absorbed water, which can be driven off by drying. Hematite is found in all stages of hydration, and thus may contain water up to the point where it should really be classed as a brown ore. Hydrated ores are thus concentrated by heating to drive off the chemically combined water. Carbonate ores are calcined to drive off both carbon dioxide and water. Some iron oxides are subjected to a partial reduction and are thus rendered magnetic, and the separation of nonmetallic impurities is thereby greatly facilitated. One brown-ore deposit that averages in the raw state not more than 30 per cent of metallic iron is thus through a complicated process of beneficiation rendered of commercial value. The question of beneficiation is therefore becoming increasingly important; and there must also be taken into consideration the proximity to transportation, and to blast furnaces, to water-power sites for possible electric reduction, as well as the prevailing conditions of the market. The laws of supply and demand that prevail in 1917 make available lower grades of ore than would be considered desirable in times when low prices for iron and steel are current. The question of quantity available is also of importance, for iron ore is so bulky a product, is relatively so low in value even at the best, and involves so large an expenditure for equipment for mining on a satisfactory scale that any deposit should contain several years' supply to be worthy of development.

To summarize, then, the ore should occur in a deposit containing several hundred thousand tons of merchantable grades, susceptible of economical mining and convenient to transportation and markets, if its development is to be seriously considered. (E. F. B.)

DETAILS OF IRON ORE PRODUCTION IN ALABAMA, 1917-1918.

The following tables show details concerning the production of iron ore in the State, together with the rank of the State in mined and marketed iron ore in 1917 and 1918:

Ore mined in Alabama, 1917-1918, by varieties, with percentage of increase in 1918 in long tons.

YEAR	Hematite	Brown ore	Total Quantity	Percentage of total U. S. Produc'n.
1917	5,949,096	1,088,611	7,037,707	9.37
1918	4,985,557	769,067	5,754,674	8.38
Decrease	963,539	319,544	1,283,033	
Percentage	— 16.2	— 29.4	— 18.2	

Iron ore shipped from Alabama mines, 1917-1918

YEAR	Quantity (Gross tons)	Value
1917	7,101,586	$13,049,535
1918	6,121,087	15,334,561
Increase or decrease	— 980,499	+ 2,285,026
Percentage	— 13.8	+ 17.5

Average price per gross ton of iron ore shipped from mines in Alabama and the United States, 1917-1918.

	HEMATITE		BROWN ORE	
	1917	1918	1917	1918
Alabama	$1.61	$2.36	$3.03	$3.55
United States	3.12	3.35	2.95	3.51

General average: 1917, $3.15; 1918, $3.39.

Rank of the first five states in mined and marketed production of iron ore in 1917 and 1918.

1917

Rank	STATE	MINED		MARKETED			
		Quantity (long tons)	Percentage of total product'n	Quantity (long tons)	Percentage of total product'n	Value	Percentage of total value
1	Minnesota	44,595,282	58.4	44,962,127	59.5	$142,901,148	60.0
2	Michigan	17,868,601	23.4	17,712,916	23.4	62,833,624	25.4
3	Alabama	7,037,707	9.4	7,101,586	9.4	13,049,535	5.48
4	New York	1,304,317	1.7	1,356,011	1.79	7,331,333	3.07
5	Wisconsin	1,202,285	1.57	1,179,709	1.56	3,913,437	1.64

1918

Rank	STATE	MINED		MARKETED			
		Quantity (long tons)	Percentage of total product'n	Quantity (long tons)	Percentage of total product'n	Value	Percentage of total value
1	Minnesota	41,953,969	60.2	43,263,240	60.0	144,706,532	58.8
2	Michigan	16,899,341	24.1	17,587,416	24.4	65,900,501	26.5
3	Alabama	5,754,624	8.27	6,121,087	8.49	15,334,561	6.18
4	New York	1,304,317	1.73	899,970	1.25	5,802,870	2.38
5	Wisconsin	1,089,351	1.56	1,167,640	1.62	3,796,408	1.53

PRINCIPAL IRON-ORE MINES.

In 1918 there were 458 iron-ore mines active, compared with 452 in 1917, and 220 mines in 1918 produced more than 50,000 gross tons of iron ore each, compared with 240 mines in 1917. The total ore produced by mines whose output was more than 50,000 gross tons each was 66,732,025 gross tons, or nearly 96 per cent of the entire production of the United States in 1918. Of these 220 mines 12 (1 more than in 1917) produced more than 1,000,000 tons of ore each in 1918. First place in 1918 was held by the Hull-Rust mine, at Hibbing, Minn.; second place by the Red Mountain group, near Bessemer, Ala.; third place by the Kerr, at Hibbing, Minn.; and fourth place by the Mahoning, at Hibbing, Minn. The production of these mines in 1918 was, respectively, 5,485,715 tons, 2,376,974 tons, 2,027,589 tons, and 2,024,675 tons, compared with 6,468,483 tons, 2,955,022 tons, 1,586,409 tons, and 2,525,145 tons, respectively, in 1917. Eight of the 12 mines producing more than 1,000,000 tons in 1918 are in Minnesota. The largest producer in Michigan in 1918 was the Norrie group, which reported having mined 1,204,698 gross tons of hematite, a decrease from the production in 1917.

The production of the Alabama mines producing more than 50,000 gross tons each in 1918, is given below in tabular form.

Iron ore mines of Alabama that produced more than 50,000 tons each in 1918.

	Name of Mine	Nearest town	Variety of Ore	Gross tons, quantity
1	Red Mountain Group	Bessemer	Hematite	2,376,974
2	Woodward, Nos. 1, 2 and 3	Lipscomb	Hematite	718,237
3	Sloss, Nos. 1 and 2	Bessemer	Hematite	502,064
4	Songo	Songo	Hematite	242,549
5	Russellville	Russellville	Brown Ore	216,611
6	Spaulding	Birmingham	Hematite	168,195
7	Raimond, No. 1	Bessemer	Hematite	128,379
8	Hammond	Hammond	Hematite	118,464
9	Greeley	Greeley	Brown Ore	113,203
10	Steinman	Steinman	Hematite	109,222
11	Irondale	Irondale	Hematite	106,074
12	Attalla, No. 1	Attalla	Hematite	102,938
13	Raimond, No. 2	Bessemer	Hematite	94,347
14	Ironaton	Ironaton	Brown Ore	57,536

BENEFICIATED IRON ORE.

Statistics of beneficiated iron ore have been gathered by the Survey for the years beginning with 1914 and, although complete returns were not at first received from every producer who subjects his ore to any form of beneficiation, the responses to the special inquiries have been, on the whole, satisfactory and interesting and have shown continued improvement.

The following processes were reported as employed to improve the quality of the ore at various mines: Crushing and screening, drying, by direct heat and by steam, hand picking on tables and on belts, washing by means of hydraulic jets and logs, jigging, electromagnetic cobbing, other concentration and separation, calcining, nodulizing, and desulphurization by sintering. Some of the operations combined two or more of these processes. Iron ores were reported as beneficiated at 101 mines in 15 states in 1918 and at 94 mines in 16 states in 1917, and in addition at the brown-ore mines of the Spanish-American Iron Co. in the Mayari district, Cuba. In addition to these processes some iron ore is recovered in the form of blast-furnace ore dust, but no statistics have been gathered on this subject. Ore so recovered has been originally accounted for in the statistics of shipments from the mines.

In Alabama the ore treated was principally brown ore, and the usual processes to which it was subjected were log washing, screening, and picking belt. A total of 986,630 gross tons of beneficiated ore, valued at $3,323,329, was marketed from 25 mines in Alabama in 1918, compared with 1,159,624 tons, valued at $3,324,715 from 19 mines in 1917. Of this quantity 340,045 tons, valued at $1,013,198, was hematite run over a picking belt.

PIG IRON.

SHIPMENTS, VALUE, AND PRODUCTION, BY STATES.

ACCORDING to reports to the United States Geological Survey by the manufacturers, the shipments of pig iron, exclusive of ferroalloys, in 1918, amounted to 38,230,440 gross tons, valued f. o. b. at the furnaces at $1,180,759,565 as compared with 38,612,546 tons valued at $1,053,785,975, in 1917, a decrease in quantity of 382.106 tons, or 1 per cent, and an increase in gross value of $126,973,590, or 12 per cent. These values represent the approximate amounts received for the iron f. o. b. at the furnaces and eliminate freight costs, selling commissions, and other items which are included in some of the market prices of pig iron as published in the trade journals.

The pig iron shipped includes the metal produced from foreign as well as from domestic ore. The quantity and value of pig iron derived from ore imported from Canada, Cuba, Spain, and other countries, although it constitutes a very small percentage of the total production, is considerable, as it is calculated that the shipments derived from foreign ore in 1918 amounted to 452,300 gross tons, valued at $15,923,400, as compared with 505,216 tons, valued at $14,381,196, in 1917. In the manufacture in 1918 of 451,000 gross tons of pig iron, 779,369 gross tons of foreign iron ore, including 89,276 tons of cinder derived from foreign pyrite, were reported to have been used, thus indicating an average pig-iron yield of 57.86 per cent, as compared with the quantity of imported ore. Domestic ore, including 5,254,687 tons of cinder, scale, and scrap, and amounting to 75,160,234 gross tons, was reported in 1918 as used in the manufacture of 37,679,786 tons of pig iron, thus indicating a yield of 50.13 per cent in pig iron from the domestic materials. The total production in 1918 of pig iron, exclusive of ferroalloys, reported to the Geological Survey was 38,130,786 gross tons.

It is possible to show for the first time in the statistics of the output of pig iron the shipments and their value at the furnaces of pig iron by the principal grades.

These figures, which do not include ferro-alloys, are given for 1918 in the second following table.

*Pig iron, including some ferroalloys, manufactured in the United States in 1917 and 1918 in gross tons.**

	1917	1918		1917	1918
Pennsylvania	15,539,728	15,198,271	Virginia	520,811	518,737
Ohio	8,518,603	8,764,132	Missouri	453,742	504,468
Illinois	3,456,915	3,440,307	Iowa		
Alabama	2,953,705	2,587,852	Colorado		
Indiana	2,657,508	3,073,599	Washington		
Michigan			Oregon		
New York	2,417,527	2;871,118	California		
New Jersey			Maryland	422,212	378,817
Wisconsin	738,541	750,866	Tennessee	369,951	369,822
Minnesota			Connecticut	10,527	12,485
West Virginia	561,951	594,675	Massachusetts		
Georgia			Maine		
Kentucky					
				38,621,216	39,054,644

*Bureau of statistics of the American Iron and Steel Institute.

Pig iron shipped from blast furnaces in the United States in 1917 and 1918.

STATE	1917		1918		Change in 1918		Percentage of change, 1918	
	Quantity (gross tons)	Value	Quantity (gross tons)	Value	Quantity (gross tons)	Value	Quantity	Value
Alabama	2,971,626	$64,309,714	2,645,179	$80,893,687	— 326,447	+$16,583,978	— 11.0	+ 25.8
Illinois	3,458,126	91,094,541	3,409,876	105,415,030	— 48,250	+ 14,320,489	— 1.4	— 15.7
Indiana	*	*	2,583,875	75,149,991	†	†	†	†
Kentucky	192,204	5,532,367	234,952	8,031,994	+ 42,748	+ 2,499,627	+ 22.2	+ 45.2
Michigan	611,446	18,300,501	502,884	17,823,684	— 108,562	— 476,817	— 17.8	— 2.6
Missouri	*	*	83,432	3,084,136	†	†	†	†
New Jersey	187,753	6,618,536	222,418	7,611,885	+ 34,665	+ 993,349	+ 18.5	+ 15.0
New York	2,276,367	52,318,661	2,482,450	70,167,542	+ 206,083	+ 17,848,881	+ 9.1	+ 34.1
Ohio	8,469,052	231,165,093	8,711,205	263,189,621	+ 242,153	+ 32,024,528	+ 2.9	+ 13.9
Pennsylvania	15,423,262	460,677,474	14,701,252	465,859,029	— 722,010	+ 5,181,555	— 4.7	+ 1.1
Tennessee	346,638	9,102,441	342,538	11,672,606	— 4,100	+ 2,570,165	— 1.2	+ 28.2
Virginia	562,299	15,703,295	453,863	15,430,473	— 108,436	— 272,822	— 19.3	— 1.7
Wisconsin	402,732	11,032,274	363,225	13,832,908	— 39,507	+ 2,800,634	— 9.8	+ 25.4
Other states‡	3,711,041	87,931,078	1,493,791	42,596,979	+†449,557	+†32,900,028	+†12.1	+†37.4
	38,612,546	1,053,785,975	38,230,440	1,180,759,565	— 382,106	+126,973,590	— 1.0	+ 12.0

*Included with "Other states."

†Increases in Indiana and Missouri included in "Other states."

‡1917: Colorado, Connecticut, Georgia, Indiana, Maryland, Massachusetts, Minnesota, Missouri, Washington, and West Virginia. 1918: Colorado, Connecticut, Georgia, Maryland, Massachusetts, Minnesota, Washington, and West Virginia.

AVERAGE PRICES.

The average price per gross ton of all kinds of pig iron, by states, from 1913 to 1918, given in the following table is based on reports of the manufacturers to the Survey. These figures represent the approximate prices f. o. b. at the blast furnaces and do not include the prices of ferroalloys.

The general average prices for 1916 to 1918 appear low for such active years in the iron industry. At the close of 1916 market prices of pig iron were between 45 and 68 per cent higher than at the beginning of the year, but this increase was confined almost entirely to the last two or three months of the year, so that the average increase in price was only 28 per cent as compared with 1915. In 1917, however, the course of prices was very different, for at the beginning and end of the year prices were more nearly the same with the high levels at the middle of the year. The regulation of prices by the Government in the latter part of 1917, which continued until after the armistice was signed in November, 1918, prevented any spectacular rise in price during this period. The general average price for all grades of pig iron at the furnaces, exclusive of ferroalloys, for the year 1918 was $30.89, as compared with $27.29 in 1917, an increase of $3.60 a ton, or 13 per cent. The States in which the average selling price of pig iron was more than $35 a ton in 1918 were Connecticut, Georgia, Massachusetts, Missouri, Michigan, and Wisconsin.

Average price per gross ton of pig iron in the United States, 1913-1918.

STATE	1913	1914	1915	1916	1917	1918
Alabama	$12.08	$10.52	$10.24	$14.59	$21.64	$30.58
Illinois	15.83	13.59	13.93	17.57	26.34	30.91
Indiana	*	*	*	*	*	29.09
Kentucky	16.09	12.24	13.44	17.97	28.78	34.19
Michigan	14.69	13.78	13.63	17.51	29.93	35.44
Missouri	*	*	*	*	*	36.97
New Jersey	*	*	*	*	35.25	34.22
New York	15.35	14.26	14.02	17.70	22.98	28.27
Ohio	15.02	13.46	12.96	15.75	27.30	30.31
Pennsylvania	15.36	13.78	13.69	17.95	29.87	31.69
Tennessee	13.22	12.05	12.09	15.13	26.26	34.08
Virginia	13.96	12.58	12.83	16.06	27.93	34.00
Wisconsin	15.18	13.35	13.20	17.77	27.39	39.08
Other states†	15.50	13.55	12.96	16.03	24.25	28.52
Average for United States	15.08	13.42	13.21	16.96	27.29	30.89

*Included in "Other states."

†1913: California, Colorado, Connecticut, Indiana, Maryland, Massachusetts, Minnesota, Missouri, New Jersey, and West Virginia; 1914: California, Colorado, Connecticut, Indiana, Maryland, Massachusetts, Minnesota, Mississippi, Missouri, New Jersey, and West Virginia; 1915: Colorado, Connecticut, Indiana, Maryland, Massachusetts, Minnesota, Missouri, New Jersey, and West Virginia; 1916: California, Colorado, Connecticut, Indiana, Maryland, Massachusetts, Minnesota, Missouri, New Jersey, and West Virginia; 1917: Colorado, Connecticut, Georgia, Indiana, Maryland, Massachusetts, Minnesota, Missouri, Washington, and West Virginia; 1918: Colorado, Connecticut, Georgia, Maryland, Massachusetts, Minnesota, Washington, and West Virginia.

MARKET PRICES.

The average monthly prices of the principal grades of pig iron either at the blast furnaces or at the nearest market during the war period, according to published market quotations, are of interest in comparison with the general average prices per ton of pig iron in the United States reported to the Survey by blast-furnace operators. Beginning at $30 a ton in December, 1916, the price rose almost steadily from February to July, 1917, when it reached $52.50 a ton, according to the Iron Age ($53.52, according to Metal Statistics). These figures are among the top prices paid for pig iron of this grade since the Civil War.

The effect of Government regulation brought down pig iron prices precipitately so that from October, 1917, until March 31, 1918, basic iron was stationary at $33 a ton. During 1918 there was no normal market. The demand for war purposes exceeded the supply but the requirements of manufacturers of war material were satisfied so far as was possible through allocations placed by Government authority. Pig-iron producers desired higher prices for the second quarter of 1918, but the War Industries Board ordered a reduction of $1 a ton, effective April 1, making basic iron $32 a ton at Valley furnaces. On October 1 all grades of pig-iron, except Bessemer, were advanced $1 a ton, by authority of the War Industries Board, the price of basic iron thus being brought up to $33 once more. Beginning October 1 a partial zoning of pig-iron prices was adopted in order to put Virginia and Tennessee blast furnaces on a more equitable basis as compared with those in the Pittsburgh and Birmingham districts, and to this end furnaces north of the Potomac and east of the Alleghenies were permitted to quote prices based on Pittsburgh and those south of Ohio and Potomac rivers were given Birmingham as a basing point.

BLAST FURNACES.

The number of furnaces in blast on June 30 and December 31 and the total number of stacks recorded for the years 1917 and 1918, not including any electric reduction furnaces, as published by the bureau of statistics of the American Iron and Steel Institute, are as follows.

Blast furnaces in the United States, 1917 and 1918.

STATE	Furnaces in blast June 30, 1917.	Dec. 31, 1917			Furnaces in blast June 30, 1918.	Dec. 31, 1918		
		In.	Out.	Total.		In.	Out.	Total.
Pennsylvania	186	122	41	163	187	127	38	165
Ohio	72	64	15	79	71	74	5	79
Illinois	22	17	7	24	24	23	2	25
Alabama	34	34	13	47	31	30	14	44
New York	21	21	4	25	24	23	4	27
Virginia	12	15	4	19	13	13	6	19
Tennessee	12	10	6	16	12	9	7	16
Colorado	4	3	3	6	4	3	3	6
Missouri	2	2	0	2	2	3	0	3
Oregon	0	0	1	1	0	0	1	1
Washington	0	0	1	1	1	1	0	1
Maryland	4	2	3	5	4	3	2	5
New Jersey	4	5	0	5	4	3	2	5
Wisconsin	6	5	3	8	4	5	3	8
Minnesota	3	3	0	3	3	3	0	3
Indiana	12	13	1	14	15	16	0	16
Michigan	12	12	2	14	11	12	2	14
West Virginia	4	3	1	4	3	4	0	4
Kentucky	4	4	3	7	5	5	2	7
Georgia	0	1	3	4	0	0	4	4
Texas	0	0	2	2	0	0	2	2
Mississippi	0	0	1	1	0	0	1	1
Cononecticut	2	2	1	3	2	2	0	2
Massachusetts	1	1	1	2	1	1	1	2
	367	339	116	455	371	360	99	459

IRON ORE PRODUCERS IN 1918.

Woodstock Operating Corp., Anniston, Ala. Mines Woodstock, Calhoun County and Woodstock, Talladega County, Ala.

Alexander Tison, Talladega, Ala. Mines at Arizola, Talladega County, Gadsden, Etowah County, Farr, Shelby County, Ala.

The Alabama Co., Birmingham, Ala. Mines at Attalla No. 1, Etowah County; Hammond, Jefferson County; Ironaton, Talladega County; Attalla No. 2, Etowah County, and Citico, Etowah County, Ala.

Citico Furnace Co., H. S. Chamberlain, Pres., Chattanooga, Tenn. Mines at Attalla No. 2 and Citico, Etowah County, Ala.

Republic Iron & Steel Co., Youngstown, Ohio. Mines at Raimond No. 1, Jefferson County; Raimond No. 2, Jefferson County; Raimond No. 3, Jefferson County; Raimond-Roup, Jefferson County; Alfretta No. 1, Jefferson County; Spaulding, Jefferson County; Tannehill, Tuscaloosa County; and Houston, Tuscaloosa County, Ala.

Sloss-Sheffield Steel & Iron Co., Birmingham, Ala. Mines at Sloss Nos. 1 and 2, Jefferson County; Irondale, Jefferson County, Russellville, Franklin County, and Compton, Blount County, Ala.

Tennessee Coal, Iron & R. R. Co., Birmingham, Ala. Mines at Fossil, Ishkooda, Muscoda, Jefferson County; Greeley, Tuscaloosa County; and Champion, Blount County, Ala.

Daniel A. Farrell, Atlanta, Ga. Mine at Dugger, Calhoun County, Ala.

Robinson Mining Co., American Trust Bldg., Birmingham, Ala. Mines at Keewanee and Glen Iris, Jefferson County, Ala.

William Siglin, Bluffton, Ala. Mine at Bluffton, Cherokee County, Ala.

J. C. Burt, Exec., Box 100, Talladega, Ala. Mine at Burt, Talladega County, Ala.

Chamblee Land & Dev. Co., Tuscaloosa, Ala. Mine at Chamblee Land & Dev. Co., Tuscaloosa County, Ala.

Columbiana Ore Co., 25 E. Baltimore St., Baltimore, Md. Mine at Nelson, Shelby County, Ala.

Woodward Iron Co., Woodward, Ala. Mines at Docray, Tuscaloosa County; Woodward 1, 2, and 3, and Songo, Jefferson County, Ala.

Jirama Ore Co., Gadsden, Ala. Mine at Tumlin Gap, Etowah County, Ala.

Birmingham-Trussville Iron Co., Jefferson County Bank Bldg., Birmingham, Ala. Mine at Crudup, Etowah County, Ala.

Birmingham Ore & Mining Co., American Trust Bldg., Birmingham, Ala. Mine at Helen-Bess, Jefferson County, Ala.

Thomas Furnace Co., Niles, Ohio. Mine at Jenifer, Talladega County, Ala.

Bass Foundry & Machine Co., Rock Run, Ala. Mines at Langdon and Weems, Cherokee County, Ala.

Cambro-Clinton Mining Corp., Jefferson County Bank Bldg., Birmingham, Ala. Mine at Watseka, Blount County, Ala.

Alabama Fuel & Iron Co., Brown-Marx Bldg., Birmingham, Ala. Mine at DeVaney, Franklin County, Ala.

Pinkney Mining Co., Russellville, Ala. Mine at Eureka, Franklin County, Ala.

Sheffield Iron Corp., Sheffield, Ala. Mine Wilson, Ryde and Hurst, Franklin County, Ala.

Shook & Fletcher Supply Co., Inc., Brown-Marx Bldg., Birmingham, Ala. Mines at Russellville Nos. 3, 4, and 5, Franklin County, Ala.

Shelby Iron Co., Shelby, Ala. Mine at Shelby, Shelby County, Ala.

Clinton Mining Co., Brown-Marx Bldg., Birmingham, Ala. Mine at Clinton (Steinman), Jefferson County, Ala.

Central Iron & Coal Co., Holt, Ala. Mines at Valley View, Jefferson County and Friedman, Tuscaloosa County, Ala.

MANGANESE.

IN 1918 the Southern Manganese Corporation exploited two deposits of high grade manganese ore in the Altoona district, Blount, and Etowah counties. This high grade ore made up more than 65 per cent of the production of the state. There were small amounts of low grade ore shipped from Calhoun, Clay, and Talladega counties.

Manganese and Manganiferous ore shipped during the years of 1917 and 1918.

YEAR	Ore containing 35 per cent of manganese or more.			Ore containing 10 to 35 per cent of manganese		
	Number of shipments	Quantity (gross tons)	Value	Number of shipments	Quantity (gross tons)	Value
1917	3	264	$10,538	—	—	—
1918	1	709	*	4	448	$8,424

*Only one producer. Geological Survey is not at liberty to publish figures.

MANGANESE PRODUCERS IN 1918.

Southern Manganese Corp., Anniston, Ala. Mines at Fields, Calhoun County, Altoona and Cave Springs, Etowah County, Ala.

Vassar L. Allen & P. King (Lessees), Birmingham, Ala. Mine at Allen & King, Clay County, Ala.

Hebert, Sewell & Pasquier, 612 Broad St., Gadsden, Ala. Mine at Lodo, Etowah County, Ala.

Nickles & Northern, Talladega, Ala. Mine at N. & W, Talladega County, Ala.

LIME.

DURING the year 1918 there was a decrease in the production of lime in Alabama, as compared with the production of the preceding year. The total product of 9 plants in 1918 was 49,209 short tons, a decrease from 1917 of 17,535 tons or 26.2 per cent.

The value of the product was $439,366 an increase of $126,835 or 33.1.

The most important use of the lime produced was for building purposes, 40.8 per cent of the product is definitely so credited in the returns while the greater part of the lime sold to dealers and most of the hydrated lime go to building purposes. Other chief uses of lime are in chemical works, paper mills, sugar factories, agriculture, tanneries, slag cement, etc.

Shelby County, as heretofore, was the largest producer in 1918. The other producing counties in the order of their importance are Blount and Jackson.

The following tables give some additional data on the lime production in Alabama in 1917 and 1918.

For a full account of the lime industry in the United States, those interested are referred to the article on Lime, by G. F. Loughlin, in "Mineral Resources of the United States, 1918."

Lime burned and sold in Alabama in 1917 and 1918.

YEAR	Rank of state by quantity	Quantity (short tons)	Value	Rank of state by value	Average price per ton	Number of plants in operation
1917	16	66,744	$383,211	17	$5.74	10
1918	17	49,209	439,366	16	8.93	9
Increase or decrease		−17,535	+ 126,835		3.19	
Percentage		− 26.2	+ 33.1		5.57	

Lime sold in Alabama in 1917 and 1918 by uses.

YEAR	Quantity (short tons)	Value	Average price per ton U. S.
1917			
Building lime	40,386	$237,410	$6.63
Chemical works	3,222	16,503	5.79
Paper mills	7,660	35,968	5.65
Sugar factories	1,210	7,459	8.08
Tanneries	*	*	6.14
Agriculture	1,791	9,816	5.07
Dealers, uses not specified	11,290	69,879	6.42
Other uses and undistributed	*	*	9.09
Total	66,744	383,211	6.29
1918			
Building lime	27,770	$257,070	$8.51
Metallurgy	6,877	56,488	7.42
Paper mills	4,663	38,808	8.08
Sugar factories	*	*	8.62
Tanneries	*	*	8.58
Agriculture	1,947	17,436	6.90
Dealers, uses not specified	*	*	8.63
Other uses and undistributed	*	*	10.97
Total	49,209	439,366	8.63
Percentage of increase or decrease in 1918	− 27.3	+ 14.4	
Hydrated lime (included in total), 1917	6,541	48,089	
Hydrated lime (included in total), 1918	6,327	61,271	
Increase or decrease of hydrated lime in 1918	− 24.1	+ 13,182	
Percentage of increase or decrease of hydrated lime in 1918	− 3.7	+ 27.4	

*Included in undistributed.

Lime consumed in Alabama in 1918.

LIME, 1918					Consumption of Lime per capita (short tons)		
	Consumed						
Produced (short tons)	Quicklime (short tons)	Hydrated lime (short tons)	Shipped out of State (short tons)	Shippd into State (short tons)	1917	1918	Population in 1918 (estimated)
49,209	18,819	2,631	31,448	3,684	.01	.01	2,395,270

Number of lime kilns in Alabama using various kinds of fuel in 1917 and 1918.

	Coal	Wood	Oil	Natural gas	Producer gas	Coke	Shavings	Coal and Wood	Coal and Coke	Total
1917	4	1	—	—	—	—	—	12	—	17
1918	4	2	—	—	—	—	—	23	—	29

KILNS.

By W. E. EMLEY.

The accompanying table contains evidence of a certain amount of confusion in the common usage of the names applied to different types of limekilns. It was thought advisable to include kilns called "shaft," "vertical," "continuous," or "gas" in the column headed "flame or patent kilns," assuming these all to be different names for the same thing. It is possible that this assumption may be incorrect.

In order to avoid such confusion in the future, and for the broader purpose of establishing a system of nomenclature within the industry, the following definitions of the different types of kilns are suggested:

A "field" kiln is distinguished from all other types by being intermittent in its operation. Firing is continued until the contents of the kiln are calcined, when the kiln is entirely emptied. Under some conditions it may be demolished and rebuilt after each burn. A "continuous" kiln is a kiln of any type other than a field kiln.

A "pot" kiln is a vertical shaft kiln which is continuous in its operation. Its peculiar characteristic is that the fuel and stone are charged into the kiln in alternate layers.

A "flame" kiln is a vertical kiln which is continuous in its operation. Its name is derived from the fact that only the flame of the fuel and not the fuel itself comes into contact with the stone or lime. This type is sometimes known as a "patent" kiln, but the term "flame" is to be preferred as more significant.

A "rotary" kiln needs no description.

The term "gas kiln" is to be avoided in this connection because it indicates the kind of fuel rather than the type of kiln.

As a part of the work of the Air Nitrates Corporation, financed by the Government, a lime plant was built at Muscle Shoals, Ala., in 1918, that was equipped with seven rotary kilns, each 8 by 125 feet.

Capacity and kind of lime kilns used in Alabama in 1918.

Capacity (short tons per day)	Pot	Flame	Rotary	Field and Unspecified	Total	Total used 1918
861	2	26	————	1	29	32

HYDRATED LIME.

There were three plants in Alabama that produced hydrated lime in 1918. The total quantity produced for this year was 6,327 short tons valued at $61,271 as compared with 6,541 tons valued at $48,089 in 1917, a decrease in quantity of 214 tons or 3.2 per cent and an increase in value of $13,182 or 27.3 per cent. The average price per ton was $7.35 in 1917 and $9.68 in 1918 an increase of $2.33 per ton or 31.7 per cent. The production of hydrated lime in 1918 was 12.8 per cent of the total production of the State.

Hydrated lime sold in Alabama in 1917 and 1918.

YEAR	Quantity (short tons)	Value
1917	6,541	$48,089
1918	6,327	61,271
Increase or decrease	— 214	+ 13,182
Percentage	— 3.2	+ 27.3

LIME PRODUCERS IN 1918.

Cheney Lime Co., Allgood, Ala. Mine at Allgood, Blount County, Ala.

W. L. Buckels, Box 402, Ft. Payne, Ala. Mine at Ft. Payne, DeKalb County, Ala.

Calera Lime Works, Calera, Ala. Mine at Calera, Shelby County, Ala.

Keystone Lime Co., Charleston, S. C. Mine at Keystone, Shelby County, Ala.

Long View Lime Works, 1116 American Trust Bldg., Birmingham, Ala. Mine at Longview, Shelby County, Ala.

Newala Lime Works, Newala, Ala. Mine at Newala, Shelby County, Ala.

Saginaw Lime & Lumber Co., Saginaw, Ala. Mine at Saginaw, Shelby County, Ala.

Milmay Lime Works, Saginaw, Ala. Mine at Saginaw, Shelby County, Ala.

O'Neals Lime Works, Eureka, Ala. Mine at Varnous, Shelby County, Ala.

MICA.

By Waldemar T. Schaller.

Introduction.

MICA is used in the form of sheet mica, splittings and ground mica. The uncut sheet of smallest practicable size, known as punch mica, should yield a disk or washer at least 1½ inches in diameter if the mica is stained and 1¼ inches in diameter if the mica is clear. The smallest "plate sheet" should yield a rectangle at least 1½ by 2 inches. Sheet mica is used in various sizes, chiefly for insulation in electric appliances, for glazing the fronts of stoves, for lamp chimneys and shades, and for phonograph diaphragms. Both domestic and foreign mica are used for these purposes. For certain high-potential electric appliances only a high-grade mica free from inclusions, cracks, pin holes, or other defects, can be used.

Splittings or films are very thin sheets of mica, about a thousandth of an inch thick. These are manufactured into built-up mica boards, such as micanite, micabeston, micabond, and micadamite. No appreciable quantity of splittings or films of domestic mica is sold, practically the entire supply of splittings consumed in the manufacture of mica board being imported. This built-up mica board is largely used in electric insulation.

Ground mica finds its chief applications in the manufacture of patent roofing, in the annealing of steel, in lubrication, and in decoration. These and other uses are described in detail below. Although some ground mica is imported, the bulk of such mica consumed, about 96 per cent, is of domestic origin. Mica has been estimated to constitute about 4 per cent of all igneous rocks, and as no special property is required of mica suitable for grinding, it is evident that any desired quantity of ground mica can be produced in this country.

The requirements for sheet mica to be used in the industries are very particular, and only a very small percentage of the total mica extracted can finally be utilized as sheet. The specifications for mica to be used in high-potential appliances, such as are used in wireless apparatus and in airplanes and automobile trucks, are very rigid.

Owing to the restrictions imposed on the importation of mica the question has arisen whether the entire demand of the country can be supplied by the domestic production. This question can not be definitely answered at present, but there seem to be grave doubts as to the domestic output being sufficiently increased.

The sheet mica imported from India has been largely used in many industries in this country and has been generally found to give very satisfactory results. Much of the domestic mica produced is said to be unfit for many of the purposes to which Indian mica is applied. An inquiry as to the possibility of domestic mica replacing imported Indian mica must have reference to the quality of the domestic mica and the quantity of suitable material which can be produced. Several large users have stated that this country contains deposits of mica which is fully as good as the Indian mica.

For the 18-year period 1900-1917 the proportion of the consumption of sheet mica (including splittings) represented by domestic production has averaged about 38.5 per cent, with extreme variations of 14 per cent in 1902 and 64 per cent in 1908. The average for 1900-1913 was 38 per cent. For the years 1903-1907, 1909, and 1912-1918 the percentages lay between 30 and 50. For the war years the percentages have shown very little change, being 41 for 1914, 40 for 1915, 40 for 1916, 42 for 1917, and 40 for 1918. In other words, there has been very little change in the ratio of domestic production to consumption of sheet mica since 1913. This ratio shows a decrease, however, as compared with the years immediately preceding 1914, except 1912, for the percentages were 44 for 1913, 30 for 1912, 59 for 1911, 56 for 1910, 49 for 1909, and 64 for 1908. For the years 1900 to 1907 the percentage was lower than 38 each year.

PRODUCTION.

The domestic output in 1918 came from 10 states, which, grouped in the order of quantity of sheet mica produced, were North Carolina, New Hampshire, Georgia, Virginia, South Dakota, Alabama, Colorado, South Carolina, New Mexico, and Wyoming. As in previous years, North Carolina led all other States both in quantity and in value of mica produced.

Percentages of mica produced in 1918 by different States.

STATE	Quantity		Total Value
	Sheet	Scrap	
North Carolina	57	46	62
New Hampshire	23	23	15
Georgia	13	2	10
Virginia	5	18	7
All other states	2	11	6
	100	100	100

The annual production of mica in Alabama for the years 1912-1918 is shown in the following table. Where less than three producers reported returns, the figures are omitted, so that no individual production is disclosed. For several years, therefore, the figures of production can not be given.

Mica produced in Alabama, 1912-1918.

YEAR	SHEET MICA			SCRAP MICA		Total quantity (short tons)	Total value
	Quantity (pounds)	Quantity (short tons)	Value	Quantity (short tons)	Value		
1912	0	0	$ 0	0	$ 0	0	$ 0
1913	*	*	*	*	*	*	*
1914	32,300	16	3,964	0	0	16	3,964
1915	8,400	4	5,545	23	395	27	5,940
1916	14,132	7	4,955	65	660	72	5,615
1917	18,476	9	3,528	0	0	9	3,528
1918	11,800	6	3,150	0	0	6	3,150

*Less than three producers. The figures may not be given.

PRICES.

Average prices per pound paid in the South for rough-trimmed sheet mica of good quality, split and sorted to cut the sizes indicated, 1914-1918.

SIZE (IN INCHES)	1914	1915	1916	1917	1918
Punch	$0.03	$0.04	$0.05	$0.055	$0.07
1½ by 2	.10	.20	.30	.40	.55
2 by 2	.25	.40	.55	.70	.90
2 by 3	.65	.70	.90	1.10	1.30
3 by 3	1.00	1.00	1.35	1.55	1.75
3 by 4	1.20	1.25	1.70	1.85	2.05
3 by 5	1.50	1.50	1.95	2.15	2.45
4 by 6	2.00	2.10	2.85	3.10	3.45
6 by 6	2.70	2.80	3.50	3.80	3.90
6 by 8	3.60	3.50	5.00	4.70	6.00
8 by 10	5.40	5.20	7.50	7.50	8.00

The average fluctuations in prices of domestic sheet mica for the year 1918 are shown in the following table:

Average prices per pound of domestic trimmed sheet mica in 1918.

Size (in inches)	January	May	July	Nov.	Dec.
Punch	$0.06	$0.07	$0.08	$0.09	$0.07
1½ by 2	.45	.45	.55	.65	.55
2 by 2	.75	.80	.95	1.00	.95
2 by 3	1.20	1.30	1.35	1.45	1.35
3 by 3	1.60	1.75	1.75	1.90	1.85
3 by 4	1.90	1.95	2.05	2.80	2.15
3 by 5	2.25	2.25	2.40	2.95	2.65
4 by 6	3.25	3.45	3.25	3.80	3.50
6 by 6	3.75	4.00	———	———	———
6 by 8	4.85	6.35	6.50	———	5.50
8 by 10	8.00	8.00	8.00	———	7.50

USES.

The different uses to which mica is put depend on its form—whether in sheets or in powder. Sheet mica is used in the electrical industry, for glazing, and to some extent for other purposes. Ground mica is used chiefly in the decorative trades, for annealing, for lubrication, and in patent roofing.

Sheet mica finds its greatest use in the electrical industry, where an insulating, noninflammable material is necessary. It is used in sheets and as washers and disks in dynamo-electric machinery, electric-light sockets, spark plugs, insulators, guards in rheostats, fuse boxes, and telephones. Flexible cloth and tape, covered with mica, find varied uses in electrical apparatus. Sheet mica is used for glazing the fronts of stoves, for furnace sight holes, for screens in front of highly heated material, for optical lanterns as a retarder of heat waves, and for making lamp chimneys and lamp shades. It is also used in spectacles (amber-colored phlogopite would seem to be the ideal material for goggles in oxy-acetylene welding), motor goggles, sand blasting, sight holes of divers' helmets and smoke helmets, compass cards, automobile shields, phonograph diaphragms, in windows where glass would be broken by heavy shocks or by vibrations as in the conning towers of warships and of submarines, and in lantern transparencies.

A peculiar silvery mica is used in India for inlay work. In India also pictures and portraits in large numbers are painted on sheets of mica.

Sheet mica has come to be of importance as a war mineral through its use as insulator in electric apparatus, especially in condensers, magnetos, and spark plugs; also as windows in masks worn for defense against asphyxiating gases, and for other uses where a transparent, non-inflammable, nonshattering material is necessary, as in automobile goggles and as coverings for wounds.

Ground mica is used for decoration in wall paper, to which it gives luster and brightness; in fancy paints, ornamental tiles, concrete, rubber goods, pipe and boiler coverings, insulating compounds, fire-proof paints and coverings, patent roofing material, molded mica (ground mica mixed with shellac), and calico printing; as absorbent for nitroglycerin in the manufacture of "mica powder;" in annealing steel; to a large extent as a lubricant for wooden bearings, or, mixed with oil, as a lubricant for metal bearings; in the manufacture of automobile treads on new tires, as well as in repair stock; and as a filler for various other products. Tar and other roofing papers are coated with coarsely ground mica to prevent sticking when they are rolled for shipment. A possible value of ground mica as a chemical source of potash salts has been suggested, especially its direct application to the soil as a fertilizer.

A recently patented insulating material, claimed to be hard and almost incombustible, is composed of 14 per cent sifted mica, 52 per cent pulverized asbestos, 20 per cent mineral caoutchouc, 10 per cent rubber solution, 3 per cent sulphur, and 1 per cent resin. The material can be molded and wrought and can be used as a substitute for porcelain, marble, slate, and vulcanized substances.

In India ground mica is used for processional ornaments, such as lamps, pottery, curtains, cloth, and tinsel decorations on fans, and in buildings, especially in temples and palaces. Large quantities have also been employed for medicinal uses—an application which has not extended beyond its country of origin.

Several trade names have been given to the mica products described below.

Micalite is applied by Eugene Munsell & Co., 68 Church Street, New York, N. Y., to the mica used in mica chimneys, candle shade protectors, and canopies.

Micanite is a term applied by the Mica Insulator Co., of Schenectady, N. Y., to a manufactured mica board or plate, built up by successive layers from many small thin films of mica, which, after being dipped into and cemented with shellac, are then subjected to pressure under heat to dry out the shellac. These large sheets are then milled to the requisite thickness and made suitable for many electrical purposes.

Micabeston, which is similar to micanite, is manufactured by the American Mica Co., of Newton Lower Falls, Mass. Several varieties are made, one of which becomes flexible when heated and rigid when cold, and is used for insulation in field coils, transformers, armatures, etc., where high heat is not generated, another variety remains rigid under a high heat and is used in commutators of generators and motors.

Micabond, made by the Chicago Mica Co., of Valparaiso, Ind., is also similar and is made in varying qualities with different properties, depending on its use.

Micadamite, manufactured by Mierowsky Bros., 106-108 Broadway, Jersey City, N. J., is similar built-up micaplate, manufactured into rings, tubes, segments, and many other forms of insulation.

These manufactured mica sheets use a number of different substances as binders in addition to shellac, chiefly paper of various grades (Japan tissue, manila, rope, fish), muslin cloth, rubber, and gutta percha.

Silberglimmer (silvery mica) is muscovite which has been heated to a sufficiently high temperature to make it softer and opaque and silvery in appearance. It is also known as annealed mica and finds a use in certain parts of electric apparatus.

Rimco is mica ground by a nonmetallic process by the Richmond Mica Co., Richmond, Va., for use as a tire powder. It is also used by manufacturers of oils and lubricating greases.

Micamima, prepared by the Crawford Mica Co., of Crawford, Nebr., is a coarsely ground mica used in the manufacture of concrete facing material; mixed with other minerals it is used to give the effect of natural rock, and it may be used for different decorative purposes.

Micolith, or micholithic, prepared by the Texas Mica Co., of Pecos, Tex., is another similar product used to give the effect of natural rock to concrete facings.

Tungash, as the Denver Mining & Manufacturing Co., of Denver, Colo., calls its products, is a bronze-colored, metallic-looking material of value for decoration. The crude biotite mica, altered and hydrated, has a dull greenish-black appearance when mined. On being heated it expands to a light product, which has a rich golden-bronze color and a decidedly metallic luster.

Clinomica is the name given by the America Mica Co., 52 Broadway, New York, to its ground clinochlore, a micaceous mineral of the chlorite group. Clinomica possesses essentially the qualities of ground mica and is used as a dusting material in the rubber and composition-roofing industries, for paints, cements, lubricants, molded electric insulation, and as a filler for various products.

MICA PRODUCERS IN 1918.

Ashville Mica Co., Biltmore, N. C. Mines in Alabama.

MINERAL WATERS.

By Arthur J. Ellis.

Character of Statistics.

THE statistics given in this report have been compiled from individual reports furnished by the owners or operators of springs and include, so far as can be ascertained, only natural waters that are bottled and sold in their natural state or only slightly altered from their natural state. Natural still waters that have been artificially carbonated, natural carbonated waters that have lost part of their carbon dioxide, and waters from which iron has been removed are included; but artificial waters and natural waters that have been flavored, concentrated, fortified, diluted, or otherwise essentially modified in chemical character are excluded if available information indicates such treatment. Water given away or consumed at spring resorts, which constitutes a large part of the annual production, is excluded. Waters sold at flat or meter rates, delivered to consumers through pipes, or otherwise obviously municipal supplies or adjuncts to them are excluded. This is the nearest practicable conformity with the commonly accepted definition of natural mineral water. No distinction is made between mineral water flowing or pumped from a natural spring and that flowing or pumped from a dug, bored, driven, or drilled well. Many of the best-known mineral waters in the United States come not from natural springs but from wells.

Distinction for statistical purposes between table and medicinal waters is entirely arbitrary. Most table waters are clear, sparkling, and without distinct mineral taste or odor; many medicinal waters are highly mineralized and have distinct mineral taste and odor. Yet some table waters are more strongly mineralized than some medicinal waters, and many medicinal waters contain less mineral matter than certain city supplies. The basis here used for distinguishing medicinal from table waters is the report regarding the spring, and this distinction is based in turn on the operator's knowledge that some of his customers buy the water to use regularly on their tables and others buy it for an aid during illness. A few strongly mineralized waters are not sold as table waters, and a few widely sold table waters are not used medicinally, but many waters are sold for both uses, though the reported sales of several medicinal waters have distinctly decreased in the last few years.

MINERAL WATER TRADE IN ALABAMA, 1918.

Returns from Alabama indicate that the mineral-water trade in 1918 was about 89 per cent less than it was in 1917. The sales amounted to 6,315 gallons, and the value of the output was $1,808, the average price per gallon increasing from 10 cents to 29 cents. There was a considerable decrease in the value of the output of table waters, from $2,072 to $120. Three springs which were active in 1917 reported no sales for 1918; three from which no reports were received were omitted; and one which was idle in 1917 reported sales in 1918. Three resorts accommodating about 185 guests were maintained. No bathing establishments were maintained and no mineral waters were used in the manufacture of soft drinks.

Sources of mineral waters sold in Alabama in 1918.

Spring or well	Location			
	County	Nearest post office	Direction from postoffice	Distance from postoffice, miles
Bladon Springs	Choctaw	Bladon Springs		
Bromberg Gulf Coast Lithia Springs	Mobile	Bayou Labatre	West	1
Gordon Mineral Springs	Escambia	Canoe	West	½
Healing Springs	Washington	Healing Springs		
Luverne Mineral 'Springs	Crenshaw	Luverne		
Matchless Mineral Water Well	Butler	Greenville	Southeast	3
White Sulphur Well	Clarke	Jackson	Southeast	1

The following tables add some details to the general statements above given:

Mineral waters sold in Alabama in 1917 and 1918.

YEAR	Commercial Springs	Quantity Sold (gallons)	Average price per gallon (cents)	Value of medicinal waters	Value of table waters	Total value
1917	13	56,270	10	$3,437	$2,072	$5,509
1918	7	6,815	29	1,688	120	1,808

Comparative production of mineral waters in Alabama in 1917 and 1918.

YEAR	Commercial Springs	Quantity sold (gallons)	Value of product
1917	18	56,270	$5,509
1918	7	6,315	1,808
Decrease	— 6	— 49,955	— 3,701
Percentage of decrease	— 46.2	— 88.8	— 67.2

A comparison of American and European mineral waters, by Alfred A. Chambers, is given in "Mineral Resources of the United States, Part II, pages 500-508." A discussion of the waters of Alabama, may be found in a report of the Geological Survey of Alabama, "Underground Waters of Alabama," by Eugene A Smith, State Geologist, 1907.

MINERAL WATER PRODUCERS IN 1918.

Bladon Springs Hotel, A. J. Prince, Prop., Bladon Springs, Ala. Spring at Bladon Springs, Choctaw County, Ala.

Bromberg Gulf Coast Lithia, Frederick G. Bromberg, Box 806, Mobile, Ala. Spring at West Bayou La Batre, Mobile County, Ala.

Gordon Mineral Springs, R. C. Gordon, Canoe, Ala. Spring at Canoe, Escambia County, Ala.

Healing Springs, H. J. Pettus, Healing Springs, Ala. Spring at Healing Springs, Washington County, Ala.

Luverne Mineral Springs Co., C. R. Bricken, Jr., Luverne, Ala. Spring at Luverne, Crenshaw County, Ala.

Matchless Mineral Water Co., H. Z. Wilkinson, Mgr., Greenville, Ala. Spring 3 mi. E. Greenville, Butler County, Ala.

White Sulphur Water Co., T. B. Pace, Jackson, Ala. Spring at Jackson, Clarke County, Ala.

NATURAL GAS.

THERE were three companies that produced small quantities of natural gas in 1918. Production of gas was reported by three companies, the gas being produced in Jefferson, Walker, and Fayette counties. There was no production of commercial importance in the State.

NATURAL GAS PRODUCERS IN 1918.

Fayette Light & Fuel Co., Fayette, Ala. Fayette County.
Dixie Gas Co., Jefferson County Bank Bldg., Birmingham, Ala. Jefferson County.
Jasper Natural Gas Co., Jasper, Ala. Walker County.

PYRITES.

QUALITIES AND USES.

THE term pyrites is the indefinite general trade name for any of the iron sulphide minerals, such as pyrite, marcasite, and pyrrhotite. Pyrite and marcasite when pure have identical chemical composition, namely, about 53 per cent sulphur and 47 per cent iron, but differ from each other in mode of crystallization. Pyrite forms cubical crystals, whereas marcasite forms tabular crystals. Pyrrhotite when pure contains about 40 per cent sulphur and 60 per cent iron, it is somewhat softer, tarnishes more readily than either pyrite or marcasite, and is magnetic, whereas the other minerals are not.

The greater part of the pyrites mined and imported into the United States is used in the manufacture of Sulphuric Acid. Pyrites, as commercially used, is generally referred to one or two classes, lump or fines. The lump ore, as its name implies, consists of pieces more than half an inch in diameter, with a certain allowable proportion of smaller particles, and is used in the condition in which it comes from the mine with little more than a preliminary crushing and sorting according to size. The fines consist of smaller particles and generally have been obtained by crushing the ore so small that the pyrites can be separated from worthless gangue by some mechanical process. They are also derived from ore that has disintegrated as a result of leaching. Owing to the different methods of treating these two kinds of pyrites for the extraction of their sulphur, they can not be used interchangeably. The lump ore commands somewhat higher prices than the fines, but, of course, it is more difficult to obtain a lump ore with as high a sulphur content as that of fines. As a result, only a few mines or parts of a mine can furnish lump ore and maintain a sufficient sulphur content, whereas suitable fines may be obtained even from deposits in which the pyrites is sparsely disseminated.

No definite lower limit can be placed on the proportion of sulphur that a pyritic ore must contain to be of commercial grade. In practice, however, material containing more than 40 per cent of sulphur is specified, and practically none of the acid companies use material that carries less than 35 per cent of sulphur.

Several elements or substances by no means rare in pyritic ores are objectionable as material to be used in the manufacture of sulphuric acid and decrease the value of the ore in which they occur, or they can be used only by means of special treatment.

Certain elements, arsenic and antimony for instance, are poisonous and have a bad effect on the resulting acid, but some of the larger fertilizer plants do not reject an ore containing less than 1 per cent of arsenic. These elements are also injurious from a manufacturing standpoint if the pyrites is used in plants making acid by the contact process, as they attack the platinum and cause it to lose its efficiency. According to Wilson,* pyrites carrying more than 8 per cent of copper can not be profitably employed in the manufacture of sulphuric acid. Carbonaceous material, such as the coal adhering to the pyrites or "coal brasses," is apparently heavily penalized by acid manufacturers because it yields acid of a dark color. This effect, however, should not prevent pyrites containing some material of this sort being used in making some low-grade acids for the manufacture of fertilizers and similar materials. On the other hand, however, most of the pyrites derived from the coal beds is marcasite, which decomposes readily, sometimes ignites through spontaneous combustion, or oxidizes to sulphuric acid, and is therefore a dangerous or expensive substance to leave in storage dumps.

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*Wilson, A. W. G., Pyrites in Canada: Canada Dept. Mines, Mines Branch, Pub. 167, p. 22, 1912.

CONDITION OF INDUSTRY.

During the year of 1918 there were several new pyrites mines opened due to the large decrease in the imports, and to the accompanying high prices of the ore. The large decrease in the amount imported was due in part to the difficulty in obtaining ships for the transportation of the ore from Spain, but was very largely attributable to the action of the Government board in issuing licenses for only a small part of the usual tonnage. Despite the fact that several new mines were opened there was only a slight increase in the domestic production during the year of 1918 as compared with the previous years. The number of tons used in the manufacture of sulphuric acid was far below the amount used in 1917, but the former users of the ore in the manufacturing of sulphuric acid altered their plans slightly and used sulphur instead of pyrites and in this way met the great demand for the acid; thus preventing the decrease in the amount of imported pyrites from affecting the American industry.

Of the total quantity of pyrites produced, 199,472 tons were reported to be lump and 265,022 tons were fines or concentrates. The total sulphur content of the lump ore was 74,504 tons, or an average of slightly more than 37 per cent of sulphur, and that of the fines or concentrates was 110,984 tons, or an average of about 42 per cent of sulphur. The value of the lump ore was $794,117, and of the fines or concentrates $1,850,398; the average price of the lump ore was therefore $3.98 a ton and that of the fines $7 a ton. According to these figures the average price per unit of sulphur in the lump ore was about 10 cents and the fines or concentrates about 16 cents.

Pyrites produced in the United States in 1918, by States.

STATE	LUMP		FINES		TOTAL	
	Quantity (long tons)	Value	Quantity (long tons)	Value	Quantity (long tons)	Value
California	*	*	*	*	111,861	$501,541
Colorado	2,947	$6,935	15,870	$108,777	18,817	115,712
Georgia	9,334	79,526	21,981	189,271	31,315	268,797
Illinois	*	*	*	*	24,369	85,659
Missouri	*	*	*	*	7,674	60,282
New York	*	*	*	*	63,982	422,968
Ohio	9,845	40,215			9,845	40,215
Virginia	85,359	233,572	58,068	607,605	143,427	841,177
Other states†	17,640	138,549	35,564	160,705	53,204	299,254
	‡199,472	‡794,117	‡265,022	‡1,850,398	464,494	2,644,515

*Output of lump and fines are not shown separately, as there are less than three producers of one or the other.

†Includes Alabama, Kentucky, Pennsylvania, South Carolina, South Dakota, Tennessee, and Wisconsin.

‡Includes quantity produced in states whose individual output may not be shown separately.

PRODUCTION IN ALABAMA.

In 1918 there were three producing pyrites mines in Alabama—those of the National Pyrites & Copper Co., the Southern Sulphur Ore Co., and the L. M. Mining Association. All three of these mines are in the east-central part of the State, in Clay County, near Pyriton. Deposits in this region have been known for some time, but the mines were reopened during 1917, and at the present time are producing a considerable quantity of pyrite.

The deposit at the National Pyrites & Copper Co.'s mine, formerly owned by the Alabama Sulphur Ore & Copper Co., is in schist and consists of irregular lenses, some of them 300 feet long and 35 feet thick. The deposit has been opened by an incline of about 30° slope for a distance of 450 feet, and the average grade of ore shipped is reported to carry about 40 per cent sulphur. Both lump and fines are shipped. The ore also carries about 1 per cent copper.

The conditions at the property of the Southern Sulphur Ore Co.'s mine are essentially the same as at the National Pyrites & Sulphur Co.'s mine, and both lump and fines, containing about 40 per cent of sulphur, are shipped.

The L. M. Mining Association has leased the old Mattison mine, about 2 miles from Pyriton. The ore body is reported to have an average thickness near the surface of about 8 feet, but this decreases in depth so that at the bottom of the shaft, which is 135 feet deep, it is only about 2 feet thick. The ore is reported to have an average content of 42 per cent of sulphur and more than 2 per cent of copper.

Each of the mines in the State reported great difficulty in getting an adequate supply of suitable labor. It is estimated that the combined production for the year was about 25,000 tons.

The general belt in which the ore bodies described occur extends for a considerable distance beyond the area prospected and seems to be worth further investigation. In Coosa County, on Hatchet Creek near Bull Gap, and at the old McGhee gold mine, some pyritic ore has been mined in the past, and probably a small quantity could be quickly obtained if required and possibly a considerable output if systematic exploration and development were undertaken. According to the State geologist of Alabama, however, the pyrites at the Hatchet Creek locality is in irregular concretionary masses and consequently is probably of rather small extent.

A large deposit of what appears to be bedded limonite derived from pyrites is reported in Shinbone Valley, 10 to 15 miles northeast of Pyriton. This appears to be a gossan and if so it is worth testing with the drill, as the indications point to a considerable deposit of pyrites beneath it. W. S. Harper, of Wedowee, Ala., owns some of the properties on which this deposit occurs. Near Stonehill, in Cleburne County, in the vicinity of the Woods copper mine, are two deposits of pyrrhotite and pyrite. The ore is in general similar to that in the Ducktown district, Tenn., and the deposit at one of the localities is said to have been traced more or less continuously for a distance of 1,200 feet. An analysis of the ore is reported to have shown a content of slightly more than 30 per cent of sulphur.

Numerous reports have been received of indications of pyrites all the way from Chilton County west of Coosa River northeastward to the Georgia-Alabama State line, but details concerning promising localities are not at hand. Some pyrites has been reported near Gold Branch, in Coosa County, also along the eastern flanks of Talladega Mountain, at the old Hog Mountain gold mine, where a vein of pyrites 10 to 15 feet thick has been reported. H. D. McCaskey, of the United States Geological Survey, also noted an apparent gossan at least 30 feet wide and possibly 50 feet wide on the south flank of Horseblock Mountain near the Chulafinnee-Abel road. This type of material trends about east and west and outcrops of it or of similar deposits have been recognized for a distance of about 2 miles. The eastern outcrop has been prospected for copper in the past but without success.

PYRITE PRODUCERS IN 1918.

National Pyrites & Copper Co., Pyriton, Ala. Mine at Pyriton, Clay County, Ala.

Southern Sulphur Ore Co., 700 Broadway, Nashville, Tenn. Mine at Pyriton, Clay County, Ala.

L. M. Mining Assn., Pyriton, Ala. Mine at Pyriton, Clay County, Ala.

SILICA.

By Frank J. Katz.

ONLY a very small silica output in 1918 was reported from Trussville, Jefferson County, Ala. The production of silica refractories, cleansing, and abrasive materials in Calhoun and Jefferson counties has ceased. The material quarried is a soft siliceous residue somewhat like the Tripoli mined in Missouri and Illinois.

QUARTZ PRODUCERS IN 1918.

Southern Silica Products Co., Birmingham, Ala. Mine at Trussville, Jefferson County, Ala.

SAND AND GRAVEL.

THE production of sand and gravel in the State in 1918 was 712,787 short tons valued at $406,973 as compared with 476,678 tons valued at $222,011 in 1917, an increase of 236,111 tons of 49.7 per cent, and an increase in value of $184,962 or 82.8 per cent. This does not include more than 40,000 tons of chert dug in the State and valued at more than $17,000.

The quantity of sand produced in the State increased from 355,533 tons in 1917 to 518,565 tons in 1918 or 43.2 per cent, and in value from $139,675 to $262,408 or 88.3 per cent.

There was a large increase in the production of gravel. The increase in the quantity was 28,133 tons or 23.1 per cent, and of $40,617 or 49.5 per cent in value. This increase in all probability was due to the construction of war-time cantonments, railroads, military highways, and other war-time necessities. Ordinary building operations were about the same as in 1917.

Building and molding sands made up 49.3 per cent of the total quantity of the sand produced; building 32.5, moulding 16.8. There was an enormous increase in railroad ballast in 1918. The output increasing from 12,690 tons to 165,131 tons in 1918, an increase of 152,441 tons or 1210 per cent, and in value from $3,014 to $82,980, an increase of $79,966 or 2656 per cent. The sand and gravel products of the State were 1.15 per cent of the total production of the United States.

The following tables give a comparison of the production of sand and gravel in 1918, and 1918, the production, and kinds of sands and gravel for these two years.

Production in short tons of sand and gravel in Alabama in 1917 and 1918.

	SAND		GRAVEL		Total'		Percentage of U. S. total
	Quantity	Value	Quantity	Value	Quantity	Value	
1917	355,533	$189,675	121,145	$82,336	476,678	$222,011	0.63
1918	518,565	262,408	149,278	122,953	712,787	406,973	1.15
Increase	163,032	122,733	28,133	40,617	236,109	184,962	
Percentage	43.2	38.3	23.1	49.4	49.7	82.8	

Quantity (short tons), value and kind of sand produced in Alabama in 1917 and 1918.

	Moulding Sand		Building Sand		Paving Sand		Engine Sand		Grinding and Polishing Sand		Railroad Ballast Sand and Gravel		Filter Sand		Total	
	Quantity	Value	Quantity	Value	Quantity	Value	Quantity	Value	Quantity	Value	Quantity	Value	Quantity	Value	Quantity	Value
1917	148,355	$54,742	157,107	$67,277	*	*	*	*	*	*	12,690	$3,014	*	$ *	476,678	$222,111
1918	119,975	47,037	230,481	128,806	*	*	*	*	*	*	165,131	82,980	2,978	3,585	712,787	406,933
Increase+ or Decrease—	—28,380	— 7,705	+73,374	+61,529	——	——	——	——	——	——	+152,441	+79,966	——	——	+236,109	+184,922
Percent'ge	— 18.9	— 14.5	+ 41.5	+ 91.5	——	——	——	——	——	——	+ 1,210	+ 2,656	——	——	+ 49.5	+ 83.2

*Concealed because of less than three producers.

per cent, whereas stone sold for other purposes (terrazzo, flux, pulverized marble, and riprap) showed a larger tonnage than in 1917.

Exact figures however for marble cannot be given as there were in 1918 as well as in 1917 only two producers.

Total value of stone (limestone, sandstone and marble) produced in Alabama in 1917 and 1918. Percentage of total U. S. value, rank of State and number of plants.

Year	Total Value	Percentage of total U. S. value	Number of Plants	Rank of State
1917	$1,611,497	1.96	29	19
1918	1,669,721	2.02	23	15
Increase in 1918	58,224			
Percentage	3.6			

LIMESTONE.

The most extensive use of the limestone produced in Alabama in 1918 as well as in 1917 was for furnace flux. Crushed stone for concrete came second, but the value was small compared with that of furnace flux. For the other uses given in the table limestone shows a slight decrease.

The limestone burned into lime or used in the manufacture of Portland cement is not taken into account here, but is included in the value of each of the finished products in whose manufacture it was used.

The total value of the limestone sold in the state in 1918 was $1,370,667 as compared with $1,278,908 in 1917, an increase of 7.2 per cent.

The value of limestone produced in Alabama in 1917 and 1918 classified according to uses of the stone is given in the following table:

the natural stagnation of construction work was thus intensified by restrictions placed by the War Industries Board upon output, labor supply, and transportation facilities. Several rock products, however, although not hailed as "war minerals," were nevertheless very essential to the successful prosecution of the war. Limestone for flux and various important chemical uses, and dolomite and ganister for refractory use were most noteworthy in this respect, and proposed novel uses of vesicular basalt for lightweight aggregate in concrete ships and of large granite blocks for the walls of acid towers illustrated other special war-time uses of "less essential" materials that bade fair to be realized, had the war continued for a year longer. These war-time uses are considered in the sections devoted to the respective stones.

Crushed stone, although its production was greatly curtailed during the war, must nevertheless be regarded as a war material. One of the first projects carried out by the National Research Council was an investigation of the materials available for rapid road construction in the States along the Atlantic and Gulf coasts. Large quantities of crushed stone were used in construction of roads in the vicinity of cantonments and other military and industrial centers where improvement of roads was of prime importance, but these were far from enough to offset the decrease in use elsewhere, which was intensified by lack of transportation facilities.

There are three kinds of stone produced in Alabama, viz; limestone, marble, and sandstone.

There was a slight increase in the value of the stone produced in the State in 1918, an increase of 3.6 per cent as compared with 1917. The greater part of this increase was in limestone supplied to metallurgical and manufacturing plants. (Mostly furnace flux). There was a decrease of 15.3 per cent in the value of the sandstone produced in 1918, as compared with 1917.

The production of marble decreased nearly 10 per cent in 1918, but the State retained its rank of fourth among the marble producing states. The quantity sold for monumental and building purposes decreased about 25 not infrequently quarried, the size of the blocks being practically limited only by the capacity of the hoisting machinery. These quarries were taken over by the Government in July, 1918, and the output of building stone was greatly curtailed. It was the plan of the Government to operate these quarries in connection with the nitrate plants in that vicinity, the stone being of the desired quality and the supply practically unlimited. A considerable amount of new machinery was placed in the quarries and operations were begun on a large scale. The quarries were returned to the owners in March, 1919.

The Oolitic variety is most extensively used for building and monumental work. It is of light gray color, uniform grain, and homogeneous texture. It possesses the quality of cheapness, it can be cut to any design required, and it is at the same time strong and durable.

If adequate machinery for doing finishing work was installed at the quarry there would no longer be any reason for going out of the State for this grade of stone. Already the material has been very extensively used in public buildings in Mississippi, Tennessee, as well as in Alabama. The only reason why it was not used in the recently erected buildings at the University of Alabama was that at the time these building contracts were let, the quarries furnished only the rough sawn stone and there was not in Alabama any establishment adequately equipped for the dressing of the stone in the quantity needed.

The above statements are confirmed by a report on the comparative tests made on the Rockwood stone, and those from Bedford, Ind., and Bowling Green, Ky., by Prof. Robert H. McNeilly, in the Engineering Laboratory of Vanderbilt University.

From this report I give the following extracts:

"GENERAL CHARACTERISTICS.—The Rockwood limestone is an almost pure oolitic limestone with frequent small crystals of calcite distributed throughout its mass. It resembles closely the Bedford stone in appearance, except that it has a slightly more open texture. The Bowling Green stone is finer in grain, softer and more easily pulverized than either the Bedford or Rockwood stones, and contains an appreciable amount of petroleum, which lends somewhat to the ease with which it is worked. In all three stones the texture is exceptionally uniform, as it is almost impossible to detect the bedding planes by eye; however in this respect the Bowling Green stone is most marked, and it is frequently necessary to test by hammer to detect which is the bed plane. Rockwood stone is lighter in color than either the Bedford or Bowling Green stones.

"CHEMICAL ANALYSIS.—The following is an analysis of the Rockwood stone made at my request by Dr. Paul C. Bowers, Chief Chemist of the Tennessee Geological Department:

	Rockwood Stone.
Moisture and loss on heating to 175° C.	0.07
Insoluble siliceous residue (SiO_2, etc.)	0.49
Oxide of Iron and Alumina (Fe_2O_3 & Al_2O_3)	0.30
Carbonate of Lime ($CaCO_3$)	98.23
Carbonate of Magnesia ($MgCO_3$)	0.97
Total	100.06

"PHYSICAL TESTS.—Comparative physical tests of the three samples of stone were made as follows:

Loss in weight on drying,
Cross bending tests,
Compression tests,
Absorption tests,
Per cent of water absorbed,
Specific gravity in bulk, and of puverized stone,
Density,
Abrasion tests.

The results of these physical tests are summarized in the CONCLUSIONS below quoted:

"CONCLUSIONS.—The above tests were made as nearly as possible, under identical conditions, and barring the accidental characteristics of the samples, which were selected at random, these results are believed to represent truly the comparative characteristics of each of the stones under consideration.

"The Rockwood stone shows itself to be a superior building stone to others in every respect except density—but even here, since its absorption of water is the lowest of the three, it should prove more durable, while the smaller weight per cubic foot can be placed more cheaply on account of freight charges.

"As compared with the Bowling Green stone, the Rockwood shows a decidedly higher strength, and characteristics which indicate a greater durability. The Bowling Green stone, however, is undoubtedly more easily worked than either of the other two stones, due to its being softer and also the presence of oil. This oil has the bad effect of staining the stone itself and the contiguous masonry for several years after it is placed, while the very ease with which the stone can be worked makes the Bowling Green very inferior where used for door sills and steps. This is shown well by the Abraision Test which shows the Rockwood stone in its best light, as a very superior material, for steps, door sills, and other places subject to wear.

"From my examination of these three stones, I believe no builder would make a mistake in using any one of the three, for they are all unquestionably very superior building stones. While each stone may have advantages over the other for some specially desired characteristics, as a building stone for general purposes, each is highly satisfactory.

Respectfully submitted,
ROBERT H. MCNEILLEY,
Assistant Professor of Civil Engineering, Vanderbilt University.

LIMESTONE PRODUCERS IN 1918.

Southern Bitulithic Co., 812 American Trust Bldg., Birmingham, Ala. Mine at Woodstock, Bibb County, Ala.

Cheney Lime Co., Allgood, Ala. Mine at Allgood, Blount County, Ala.

Gulf State Whiting Co., Mobile, Ala. Mine at Glendon, Clarke County, Ala.

C. M. Noble, Anniston, Ala. Mine at Cobb, Etowah County, Ala.

The Alabama Co., Birmingham, Ala. Mines at Rock Springs and Glencoe P. O., Etowah County, Ala.

Woodstock Operating Corp., Anniston, Ala. Mine at Rock Springs, Etowah County, Ala.

Foster & Creighton Co., 807 First Nat. Bank Bldg., Nashville, Tenn. Mine at Rockwood, Franklin County, Ala.

Gulf States Steel Co., Boyles or Birmingham, Ala. Mine at Boyles, Jefferson County, Ala.

Warrior Timber & Contracting Co., C. McCormack, Pres., 226 Woodward Bldg., Birmingham, Ala. Mines at Boyles and Gate City, Jefferson County, Ala.

Dolcito Quarry Co., R. D. No. 6, Box 500, Birmingham, Ala. Mine at Dolcito, Jefferson County, Ala.

McDonough Ore & Mining Co., 540 Brown-Marx Bldg., Birmingham, Ala. Mine at Gate City, Jefferson County, Ala.

Tenn. Coal, Iron & R. R. Co., Brown-Marx Bldg., Birmingham, Ala. Mines at Ketona and Vanns, Jefferson County, Ala.

Sloss-Sheffield Steel & Iron Co., Birmingham, Ala. Mine at N. Birmingham, Jefferson County, Ala.

Republic Iron & Steel Co., Birmingham, Ala. Mine at Thomas, Jefferson County, Ala.

W. B. McCulloch, R. D., Albany, Ala. Mine at New Decatur, Morgan County, Ala.

Keystone Lime Co., Charleston, S. C. Mine at Keystone, Shelby County, Ala.

MARBLE.

The marble of Alabama is of two kinds, crystalline, or true marble, and non-crystalline.

The crystalline or statuary marble occurs mainly in a narrow valley along the western border of the metamorphic area, extending from Marble Valley in Coosa County, through Talladega into Calhoun. The length of the marble belt through Coosa and Talladega counties is about 50 miles. The width of the valley carrying the marble as a rule is from one-quarter to one-half mile, widening in places to a mile and a quarter, for example in the neighborhood of Sylacauga.

The quarries longest known are Gantt's and Herd's near Sylacauga, Nix's near Sycamore, Bowie's near Rendalia, and Taylor's and McKenzie's near Taylor's Mill, east of Talladega. From all of these marble was quarried before the civil war.

During 1918 two companies reported production of marble in Alabama, viz., the Alabama Marble Company at Gantt's Quarry and the Moretti-Harrah Company, whose quarry adjoins that of the Alabama Marble Company at Gantt's. The other quarries mentioned are in Talladega County, near Sylacauga.

The plant of the Alabama Marble Company at Gantt's Quarry which was completely destroyed by fire in December, 1910, has been rebuilt and equipped with all the machinery needed for the working up of any kind of finished product.

I think it is fairly safe to say that on the whole the marble from this quarry and immediate vicinity is of the highest grade of commercial white marble now on the market and obtainable in large quantity. There are small quantities of marble produced both in Italy and Vermont that are somewhat freer from coloring matter than the best grades that can be produced in Alabama in any quantity. But on the other hand, the poorest grades in Alabama greatly surpass the poorest grades produced elsewhere, so that the average of the Alabama deposit is probably somewhat higher than that of any other so far developed, not excluding even the marble from the Carrara district in Italy. The marble from this State (Gantt's Quarry) has now a well established reputation and has been used in more than 200 important buildings throughout the United States.

It can be seen in the galleries of the National Museum in Washington.

The Moretti-Harrah Company furnishes the marble in blocks for monumental and rough interior purposes.

A beautiful quality of variegated limestone or marble—red, pink and white—belonging probably to the Cambrian formation, occurs in Shelby County, a mile or two south of Shelby Springs station on the L. & N. railroad, and extending thence southwest for a mile or two. Nothing but prospecting work has been done on this marble. The Trenton limestone in the Appalachian valleys, particularly Jones Valley below Bessemer, contains marble similar to that quarried in the vicinity of Knoxville, Tenn. Also at Pratt's Ferry on the Cahaba River in Bibb County a quarry was for many years worked in this formation and turned out a very beautiful quality of marble varying in color from gray through pink, red and brown shades.

A black marble which is exceedingly promising, has been reported and some development work done near Anniston, and at Piedmont, Calhoun County, and some very handsome specimens of cave onyx have been obtained from near Kymulga in Talladega County.

In the Coastal Plain the St. Stephens limestone of the Tertiary holds ledges of hard, almost crystalline rock capable of taking good polish. The colors vary from nearly white, through shades of yellowish into red, and it would make a handsome decorative marble, especially for inside work.

Other limestone formations, such as the Subcarboniferous and the Knox Dolomite, could in places be drawn upon for marble.

MARBLE PRODUCERS IN 1918.

The Alabama Marble Co., Gantts Quarry, Ala. Quarry at Gantts Quarry, Talladega County, Ala.

Moretti-Harrah Marble Co., Sylacauga, Ala. Quarry at Sylacauga, Talladega County, Ala.

SANDSTONE

The returns from the State to the U. S. Geological Survey office shows a decrease of $2,614 in the total value of sandstone produced in 1918 or 15.3 per cent as compared with the previous year.

By far the greater part of the sand stone produced in Alabama in 1918 was ganister from Rock Run Cherokee County.

The following table will show the limestone and the sandstone production of Alabama from 1913 to 1918, inclusive.

Value of limestone and sandstone production in Alabama, 1913-1918.

KIND	1913	1914	1915	1916	1917	1918
Limestone	$812,664	$787,214	$426,266	$917,559	$1,278,908	$1,370,667
Sandstone	151,111	161,778	30,482	20,995	17,098	14,484

SANDSTONE PRODUCERS IN 1918.

Harbison-Walker Refractories Co., Pittsburgh, Pa. Quarry at Rock Run, Cherokee County, Ala.

J. Black & Sons, 3rd Ave. and 19th St., Birmingham, Ala. Quarries at Woodlawn and Birmingham, Jefferson County, Ala.

W. W. Brooks, Hartselle, Ala. Quarry at Hartselle, Morgan County, Ala.

U. S. Engineer's Office, Tuscaloosa, Ala. Quarry at Lock 12, Warrior River, Tuscaloosa County, Ala.

SUMMARY.

BECAUSE of the difference in the units of measurement employed in the various branches of the mineral industry, a summation of the production of the year can include only the values of the products. It is also to be noted that a simple summation of all the values of the minerals or mineral products listed in this pamphlet would give a value much in excess of the true value, since in many cases, as for instance coal and coke, and iron and pig iron and steel, the second product is directly a product of the first, and the value of the first is included in that of the second. To give the values of both as a part of the total would be to repeat, in a measure, at least a partial value of the first or raw product and would give an erroneous result.

As the Survey has not, however, the figures upon which to base an estimate of the percentage of each product which was used in the manufacture of some other product, the summation of the mineral production of the State as here given will be a simple summation of the values reached by the individual branches of the industry.

According to this rather unsatisfactory manner of summation, which does not include the value of the steel produced, the value of the 1918 raw materials and immediately derived products was $189,426,896 as compared with $158,127,150 in 1917 an increase of $31,299,746 or 19.8 per cent.

The production may be classified as follows:

Raw products	$77,719,831
Pig Iron	80,893,687
Coke	30,813,378
Total	$189,426,896

The more important minerals and products after coal, pig iron and coke, are iron ores, clay products, stone, cement, sand and gravel, and lime given in the order of their relative importance.

Below is a tabular presentation of the value of the mineral products of Alabama, as estimated above for the years 1912, 1913, 1914, 1915, 1916, 1917 and 1918.

Year	Value
1912	$ 60,141,793
1913	67,530,089
1914	56,769,559
1915	61,791,958
1916	94,987,229
1917	158,008,952
1918	189,426,896

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GEOLOGICAL SURVEY OF ALABAMA

(EUGENE ALLEN SMITH, State Geologist)

BULLETIN NO. 24

MICA DEPOSITS OF ALABAMA

by

[illegible]
[illegible]

UNIVERSITY, ALABAMA
[illegible]

NOV 21 1921

GEOLOGICAL SURVEY OF ALABAMA
EUGENE ALLEN SMITH, *State Geologist*

BULLETIN NO. 24

MICA DEPOSITS OF ALABAMA

BY
GEORGE HUNTINGTON CLARK
ASSISTANT GEOLOGIST

UNIVERSITY, ALABAMA
1921

PRESS
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ALABAMA

LETTER OF TRANSMITTAL

UNIVERSITY, ALA., SEPTEMBER, 1921.

HON. THOMAS E. KILBY,
Governor of Alabama,
Montgomery, Alabama.

Sir: I have the honor to transmit herewith the manuscript of a Report on the Mica Deposits of Alabama by George Huntington Clark, with the request that it be printed as Bulletin No. 24, of the Geological Survey of Alabama.

Very respectfully,

EUGENE A. SMITH,
State Geologist.

GEOLOGICAL CORPS.

Eugene Allen Smith, Ph.D.	State Geologist
William F. Prouty, Ph.D.	Assistant Geologists on Special Work.
George I. Adams, D.Sc.	
George H. Clark, C. E.	
Robert S. Hodges	Chemist
Roland M. Harper, Ph.D.	Geographer and Botanist
Mrs. Herbert H. Smith	Acting Curator of Museum
Truman H. Aldrich	Honorary Curator of Mollusca
Rev. H. E. Wheeler	Assistant in Paleontological Work
George N. Brewer	Field Assistant
A. T. Donoho	Secretary

RIVER GAGE HEIGHT OBSERVERS.

Tallapoosa River at Sturdevant, Ala.

A. L. Stow.....Alexander City, Ala.

Elk River at Elkmont, Ala.

Dr. William E. Maples.....Elkmont, Ala.

Observations are made every day by these observers of the gage readings at the several stations. From these records when extended through sufficient time, the calculation of available horse power to be obtained from the different streams is made.

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THE MICA DEPOSITS OF ALABAMA

PART I.

GENERAL DISCUSSION.

INTRODUCTION.

FROM its indispensable character in many vitally important industries, and by reason of the failure as yet to find or provide a satisfactory substitute for it in certain of its most important and rapidly increasing uses, mica has become one of the most essential and therefore valuable of all the mineral products.

Although one of the most widely distributed of all minerals as a component part of the various rocks, workable deposits of mica, from which may be recovered the grades and the quality chiefly in demand, are not only limited in number, but are also at very many points of origin, inaccessibly located with respect to transportation, and largely handicapped as to economic recovery by the irregularities and uncertainties always incident to its mode of occurrence.

Of the distinct varieties of mica occurring in the United States, six have been to greater or less extent mined, viz: muscovite, phlogopite, roscoelite, lepidolite, biotite, and mariposite. Only two of these varieties, muscovite, and phlogopite, have received any general application in the industries, and have constituted therefore the major part of present mine recoveries.

As regards extent and availability, and their more comprehensive uses, indispensable to the electrical industry as a vital factor in its enormous expansion, the varieties of muscovite, having the same chemical composition and varying only in physical characteristics, are the basic factors at the present time in domestic mica mining and manufacturing.

Phlogopite, next in order of commercial importance, is of small and infrequent domestic occurrence, the supply being largely imported and mainly drawn from Canada.

Biotite, occurs to some extent in Alabama mica mines, but not in recoverable amounts.

Roscoelite has value only as a source of vanadium, and lepidolite mainly as containing a small percentage of lithium. Mariposite finds limited uses in the arts by reason of its color. None of the last named varieties have been as yet identified or have received any attention in this State.

PRODUCTION.

Prior to the Great War, the world's supply of mica had been largely drawn from India, Canada, and the United States, with lesser but considerable amounts supplied mainly from Brazil, Southwest Africa and Ceylon.

The United States during the pre-war period, was never able to produce more than forty per cent. of its consumption of sheet mica, and in the higher grades, meeting the requirements for high-potential electrical uses, its maximum production fell far short of that percentage of its requirements.

As the estimated total annual consumption and production of sheet mica approximately balance, practically all the sheet mica annually mined, being consumed; the necessities for the carrying out of Government orders alone, wholly irrespective of other requirements, for the year 1919, called for at least 1,000,000 pounds, or 500 short tons, of which amount three-fourths necessarily therefore, required to be imported muscovite. Average annual domestic requirements under normal conditions prior to the war, having approximated 1700 tons of sheet mica, substantial increases in production under the stimulus of the relatively higher level of war prices were imperatively demanded and confidently looked for but were only partially realized.

Similar shortages, and the necessity for speeding up production under the war regime but under more difficult conditions of realization, existed also coincidentally abroad, and were necessarily of world-wide extent.

The comparatively small increment realized in world production of sheet mica, however, under the heavy pressure brought to bear on this industry by reason of existing war necessities and conditions, may in some measure indicate, with due and proper consideration of the difficulties and obstacles incident to such a sudden and wholly unexpected demand for heavily augmented output of existing mines, possible definite limitations in the sum total of mica reserves as at present known.

World production of sheet mica, averaging at the present time about 3,000 short tons annually, is derived from the following definite sources as to its distribution nationally.

North America: United States, Canada, Guatemala, and Mexico. *South and Central America:* Brazil, Argentina, Chile, Costa Rica, and Peru. *Europe:* one source only, Norway. *Africa:* German East Africa, Union of South Africa, Madagascar, Nyassaland Protectorate, Rhodesia, Protectorate of Southwest Africa, and Kamerun. *Asia:* India, Ceylon, Chosen, China, Japan and Siberia. *Australasia:* Australia and New Zealand.

The chief source of the world's supply of sheet mica is now and always has been India, where the industry originated several centuries ago, and where there are at the present time over 15,000 men, women and children employed in mica mining and handling.

The continuous and steady growth of the industry in India has been due to the outstanding facts, that from its long and regular period of operation, the difficulties and obstacles in the way of successful mica mining are there better understood and more competently dealt with, low cost labor is abundant, satisfactory, and sufficiently skilled, and the necessary processes of preparing and of grading mica stocks prior to shipment, are properly made use of; a vital condition for successful operation, singularly lacking in very many attempted mica recoveries elsewhere. Beginning with the first reliably recorded output in 1890, of 346 short tons, the average annual production from 1901 to 1917 was 1823 short tons, reaching a maximum of 2579 short tons in 1918, confined largely to the Bihar and Orissa Fields, which in final analysis means; that during the above defined period, India furnished over 60 per cent. of the world's sheet mica. amounting to practically three-fourths of the world's sheet muscovite, as against a coincident and relative production in the United States of less than 20 per cent. When it is remembered, however, that the average labor cost for men, women and children in the East Indian mica district averages less than 30 cents per diem, and that the product of this field, re-shipped from England, has benefited by the further advantage of ruling and favorable exchange rates, the above stated relative percentages become more understandable. Of the total sheet mica output, Bengal has supplied about three-fourths, the remainder being drawn from Madras, with the exception of very small amounts from Rajputana.

Prior to the war, although considerably over half of the sheet mica exported from India went uniformly to the United Kingdom, its ultimate consumption after re-shipment, is difficult to trace. It is stated, and seems probable, that Germany at that time absorbed the larger part of it, the United States, by direct and indirect shipments, receiving not much more than one-fourth of such exports.

Systematic study, given to the mica industry by the India Geological Survey during the war, with a view to pointing out and opening up new occurrences, and to the re-working of the old mines by new and more efficient methods, tends to show that the future of mica mining in India is very promising, and would seem to indicate that if the present preferential conditions as to mine cost and available markets continues, that country may easily sustain its present lead in production.

As regards American consumption, Canada is practically the only commercial source of phlogopite, although small amounts have at various times been recovered from Ceylon, Madagascar and South Africa.

Expressed in terms of sheet mica, inclusive of splittings, its precise quota of world's production is difficult to estimate, owing to the form of the statistical information available as published by the Canadian government. Assuming however, one-half of the total production reported to be sheet mica; that is cut, uncut, and splittings, the output of the Canadian mines for the period 1906 to 1917, is approximately stated at 11 per cent. of the world's production, averaging annually for that period about 357 short tons, with but small fluctuations. Very little of the India mica mined is consumed locally. For the period 1912 to 1916, 81 per cent. of its output exported, went to the United States, and 17 per cent. to Great Britain.

South American exports, negligible before the war, have recently made notable advances chiefly in Brazil and in Argentina. In Brazil, the mica deposits, located fairly accessibly to railroads for transportation to port, mainly in the adjacent and contiguous states of Bahia, Goyaz, Minas Garaes, and Sao Paulo, have received recent increased development, considerable amounts of mica being recovered from them during the war period, comparing favorably as to grade with India mica, and running in size up to large plates 20 by 10 inches, with supplies indicated as obtainable, 6 by 6 inches in size. The interior Province of Goyaz, while much less accessible, has been recently reported to contain very large deposits, the natives having long used it for window panes. The output of the Brazilian mines prior to 1913 was negligible, amounting to less than 10 tons per year. Under war stimulus however, and because of the excellent quality of the mica produced, its output has heavily increased, amounting in 1917 to 106 tons, or nearly 3 per cent. of the world's production, and 10 times its pre-war recovery.

The proportion of Brazilian mica coming to the United States has always been large and is increasing, considerable capital has been invested, and present production may be maintained in spite of existing difficulties due to serious lack of transportation facilities and of efficient labor, and to unfavorable climatic conditions.

The mica deposits in Argentina lie mainly in the remote and difficultly accessible mountain provinces of Cordoba and San Luis, and not having been competently developed, shipments made have generally been of inferior grade, known and classified as stained or spotted mica. Recent shipments of muscovite have, however, included some good clear sheet mica, the available percentage of which may be subject to material increase although still inferior to similar Brazilian grades. The average annual production for the period 1908 to 1913, was approximately 10 short tons, amounting in 1917 and 1918, to about 2 per cent. of the world's production. Of this production the United States received less than half, most of the residue going to England.

Peruvian production and exports have been thus far so small as to be negligible. Shipments made mainly in an experimental way from Guatemala, have not proven generally satisfactory, the mica recovered being of greenish color, splitting badly, and proving after test unsuitable for electrical purposes. As the cost of production is exceptionally high, owing to unfavorable mining conditions in respect to occurrence, insufficient labor, and defective transportation, no material increase in the recovery of mica of acceptable grade is at present probable from the Guatemalan District, although recent exploitation by surface workings only of new deposits in the Department of Quiche, developed some mica of better grade running to larger sizes.

Production is Norway, confined to one locality near Skutterud, on the southwestern coast, has been justified during war conditions only, and is not likely to be continued, as the mica recovered has been mostly small and of inferior quality.

African production of sheet mica, although distributed over an extremely wide area, is mainly confined as to probable permanence and present importance, to former German East Africa, where mica occurs in ten different localities, the most valuable deposits being found in the Uluguru mountains. The sheet mica recovered has been of high grade, dark green or brown muscovite, unusually clear and transparent, largely free from imperfections, and occurring very frequently in large crystals. Limited amounts of phologopite have also been recovered, but of generally inferior quality and of small commercial value.

The output of German East Africa, from 1908 to 1913, averaged 127 short tons, constituting in 1913, 4.3 per cent. of the world's production. During the war, this production was materially increased advancing this District to fourth place, (after India, the United States, and Canada), in production of sheet mica, and making it third in importance, on the basis of the actual value of world output of sheet muscovite.

In the Union of South Africa, practically all the known deposits of value are in the Transvaal, existing operations having been confined to three localities. The mica recovered has been commonly of large size but of somewhat defective structure in the crystals, limiting the amounts of recoverable sheet in these larger books. The brownish muscovite of the Leydsdorp field, however has proved to be equal to the best grades of Indian and Canadian mica for electrical purposes. In recent Memoir No. 13 of the Geological Survey, Department of Mines and Industries, Union of South Africa, a mica belt is reported of some 300 square miles in area, which has been worked to a considerable extent since 1909, but until the opening of the Selati Railway in 1912, which now crosses the mica field, the nearest railway shipping point has been 120 miles distant. In reviewing the operations of six operating companies, the finding of some exceptionally large blocks is noted, but as a whole the merchantable mica recovered, although of favorable grade, is stated to have been mainly in comparatively small sizes. Some idea of mining conditions and cost of recovery may be gained from the stated fact in Memoir No. 13, that to procure one ton of mica, trimmed and in marketable condition, it has here been found necessary to mine from 850 to 1700 tons of rock. Also the great waste in this field, suitable for grinding purposes, has been practically unused. During the period 1909 to 1917, the Transvaal output, averaged annually only about four tons. Recent export figures, although not as yet available, would probably not show this field of much relative importance.

Only small production is noted from the Island of Madagascar, the last annual output reported in 1913 being 6 tons, although something like 125 tons per year is stated to be a possible expectancy. The mica mined consists of both muscovite and phlogopite. Only a small proportion of the muscovite is clear sheet, the greater part of it being discolored or spotted. With the exception of the Nyassaland Protectorate, which has produced some little clear sheet; the remaining Africa mica fields in Rhodesia, Kamerun, and the Protectorate of Southwest Africa, are of no commercial importance.

Of the Asiatic deposits, the known occurrences outside of India have practically as yet no tangible commercial value. Ceylon, as far as known has an annual output averaging only about 5 short tons, with a reported maximum in 1907 of 23 tons made up altogether of phlogopite, the grade of which has not as yet been demonstrated. Chosen, (Korea) has long produced small amounts of both muscovite and phlogopite, which have been altogether made use of locally. China contains some large deposits, mainly remote from transportation, but the grade of mica recovered from such deposits as have received exploitation has been inferior, and the extent and value of existing mica reserves has yet to be altogether proven.

Japan has as yet no developed mica resources of which any definite knowledge has been obtained, and it is questionable whether such resources exist although reported to be present, in as much as the rapid growth of the electrical industry in Japan, which has in recent years changed it as a nation from an exclusive importer to an exporter of electrical goods, would have probably brought about the development of such mica resources if in existence.

Siberian deposits have recently received some attention, muscovite in the clear sheet, mainly small, but of occasional very large sizes, having been mined, but by reason of climatic drawbacks and remoteness from transportation, are hardly to be considered as present sources of supply.

Australia carries very extensive and workable deposits of sheet mica mainly in the central part of the island, the muscovite recovered being in large, clear sheets of light color, unusually free from flaws or imperfections, sheets running from twelve inches to several feet in width having been mined. It has been stated that the Harts Range deposit is one of the largest and most important mica deposits known to exist, although the comparatively small known present production indicates as yet a limited development.

Western Australia, in addition to valuable deposits of muscovite sheet mica, carries also notable deposits of lepidolite in the clear sheet, running to large sizes. South Australia realized a production in 1917 of 38 tons, which was however of indifferent grade, and of low value. Queensland has had no stated figure of production, the deposits opened up and which carried good muscovite, lying too remote from transportation to justify present development.

The mica produced and sold in the United States,[*] as reported to the United States Geological Survey, amounted in 1918 to 3114 short tons, and the sheet mica marketed, to 1,644,200 pounds, an increase in quantity of 29 per cent. over 1917, but a decrease of nearly 3 per cent. in estimated value. The quantity and value of scrap mica produced—2,292 short tons—were the smallest reported since 1906. During the first nine months of 1920, the industry was prosperous, with corresponding resultant production, but with the general industrial decline during the last quarter, market demands rapidly declined, and prices dropped from 10 to 20 per cent. Importations for the first 10 months of 1920 were nearly double those of the preceding year, amounting to 1,375,927 pounds of uncut mica valued at $1,206,443, and of cut mica to the estimated value of $1,656,182. Exports of mica for the same period mainly in the form of manufactured products, were valued at $242,381, or about 10 per cent. of the value of imports. As a result of these heavy importations, at prices largely eliminating domestic competition, production during the closing months of 1920 declined heavily, North Carolina mines furnishing the bulk of the American output, being at present largely idle, and hundreds of men and women dependent altogether on the mica industry for the means of subsistence have been thrown out of employment. It has been estimated from reliable sources that the South alone, possessing mica resources largely undeveloped and favorably conditioned, is capable, under merely a reasonable and fair temporary measure of tariff protection, of mining and of shipping mica to the value of five million dollars annually.

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[*] U. S. Geological Survey Mica in 1918.

Ten states furnished the production reported for 1918, being in the relative order of the sheet mica recovered, North Carolina, New Hampshire, Georgia, Virginia, South Dakota, Alabama, Colorado, South Carolina, New Mexico and Wyoming. North Carolina, as always heretofore, furnished more than half of the recovered product, both in respect to amount and value; New Hampshire approximately one-fifth; Georgia about one-tenth. Precise figures of production during 1919 and 1920, are not as yet available. Of the states named, and from such data as has been obtainable, it seems indicated however, that North Carolina and New Hampshire have about maintained their annual average, Georgia under war stimulus, having shown a marked and surprising increase, notably in the Thomaston district. It has been recently stated by Mr. Courtenay DeKalb and others familiar with recent Georgia developments that its record-breaking war period increase in output can be maintained, and that it is capable of being made one of the largest of the mica producing states. Virginia, in 1918, practically doubled its 1917 production. Alabama's output showed a decline, and South Dakota, South Carolina, and Idaho, no appreciable production, as was the case also with Colorado and Wyoming.

Among the minor producing states, a possibly important increase in production, having some distinct possibilities, is reported during 1920 from New Mexico, where in the Petaco District the El Paso Mining Company, operating mines in Rio Arriba County, developed a pegmatite body, (stated to be unusually wide and persistently micaized) by some 1,000 feet of drifts, recovering therefrom mica of fair sizes and of good quality in amounts not stated, as the output of the mines has been altogether manufactured into specialties by the operating company. Outside of the ten producing states from which recognized production has heretofore been drawn, mica occurrences, undeveloped, and therefore of no present known importance or value, have been noted in an equal number of other states.

World production is altogether compiled and stated on the sheet mica basis, for the reason that outside of the United States, and in lesser degree Canada, the mica recovered, being almost altogether exported to some point of manufacture, is clear sheet of good quality.

In domestic production, no information is available for comparison as to the precise amounts of such clear sheet, owing to the fact that compiled statistics; which must necessarily base upon such incomplete returns as mine operators can be induced to furnish, make no separation in amount in most cases between the various grades of clear, defective, cut and uncut, punch, washer, and run-of-mine,, the gross amounts only being obtainable as reported.

In the report of the U. S. Geological Survey on Mica in 1918 by Waldemar T. Schaller, from which the statistical and other data here given are largely quoted, compiled statistics have received a most comprehensive and instructive analysis, in which upon an assumed (but indicated as proven) basis, of a yield of one pound of cut mica to every three pounds of uncut, the total production for 1918 of uncut mica larger than punch, would approximate 700,000 pounds.

An instructive and valuable determination by analysis of the actual percentages of the different sizes of uncut sheet mica entering into the above stated figure of total production, is also made by Mr. Schaller in this 1918 report, based upon an available aggregate amount of 150,000 pounds on which precise and accurate data had been reported, these percentages applying only to uncut sheet larger than punch, and working out as follows: 1½ by 2 inches, 31 per cent; 2 by 2 inches, 25 per cent; 2 by 3 inches, 23 per cent; 3 by 3 inches, 8 per cent; 3 by 4 inches, 5 per cent; and of larger sizes, 8 per cent.

Applying the percentages by sizes so obtained to the estimated total production of uncut sheet, inclusive of uncut punch, and reducing all cut mica to its approximate equivalent (three times), of uncut mica, the following important tables are further deduced by Mr. Schaller, which will serve to show as to relative sizes the possibly fair averages of sizes actually realized in most domestic mine operations.

Estimated production of Sheet Mica in the United States in 1918, by sizes.

	Pounds.
Punch	1,175,000
1½ by 2 inches	217,000
2 by 2 inches	175,000
2 by 3 inches	161,000
3 by 3 inches	56,000
3 by 4 inches	35,000
Larger sizes	56,000
Splittings	11,000
	1,886,000

The percentage yield of cut mica according to use, applied to the 700,000 pounds of estimated production of uncut sheet mica larger than punch, would represent approximately the following yield of domestic cut mica for 1918:

Approximate yield of cut mica larger than punch in the United States in 1918.

	Pounds.
Cut condenser mica	91,000
Cut electric mica	84,000
Cut stove mica	28,000
Other cut mica	21,000
Scrap from cutting	476,000
	700,000

These quantities would represent a maximum, as the 700,000 pounds of mica include the 1½ by 2 inch size, (too small for condenser mica), and include also all grades from the clear, to the heavily stained and spotted. The 91,000 pounds of condenser mica, may therefore be taken as the approximate maximum annual quantity of that grade that this country could produce under 1918 conditions. It is easy to see that the domestic mica was not then sufficient to supply the demand for condenser mica, which amounted to many hundred thousand pounds in 1918, and was expected to be nearly a million pounds in 1919, if the military program had continued in full force.

STOCKS.

With the exception of splittings, the domestic consumption of which is almost altogether imported, practically no sheet mica stocks whatever are held in this country which could be at all regarded in the nature of reserves, the small stocks accumulated being only sufficient in a general way to provide for fluctuating market requirements.

CONSUMPTION.

Briefly summarized, the detailed figures of consumption compiled by the U. S. Geological Survey conclusively show that the world's annual consumption and production virtually balance, there being little or no recovery of used mica, and practically all mica mined being consumed.

The percentage of world's production represented by consumption of sheet mica in the United States from 1910 to 1917 inclusive, is stated at 48¼ per cent. The annual consumution of sheet mica in the United States, is approximately stated at present as 1700 short tons, less than half of which is domestic output, by far the larger part of the imported remainder being splittings.

Expressed in percentages as to its uses; of the domestic uncut sheet mica mined in all sizes, 71 per cent has been utilized for electric insulation, 23 per cent for stove fronts, 2 per cent for phonograph disks, and 4 per cent. for other purposes. Of the imported uncut muscovite sheets, exclusive of splittings, 82 per cent. has been consumed for electrical insulation, 5 per cent. for stove fronts, 6 per cent. for phonograph disks, 4 per cent. for lamp chimneys and canopies, and the remaining 3 per cent. for other uses.

These estimates of relative percentages as deduced by the United States Geological Survey indicate that about 45 per cent. of the total uncut sheet (excluding splittings) is finally used in the finished form, the remaining 55 per cent becoming only scrap suitable for grinding. As also stated by Mr. Schaller, normal world's consumption of sheet mica (inclusive of splittings) prior to 1914, had been estimated to be 7,000,000 pounds, or 3,500 short tons, of which amount the United States consumed 1700; Germany, 800; Great Britain, 400; India, 400; France, 100; Italy, 50; and all other countries 50 short tons under approximately normal conditions obtaining during the period indicated. Present consumption when known will reflect the increase due to the large and continuously world wide expansion of the electrical industry.

No reliable figures have ever been available as to the total amounts of world's consumption of mica splittings. which in 1919 was estimated as being 1111 short tons, of which aggregate estimate, India is stated as utilizing 663; Canada, 376; and the United States only 72 short tons.

No accurate figures showing the actual consumption of scrap and of ground mica are available, either of world utilization, or in the United States, the actual consumption being greater than is recorded by reason of the increment derived from mica trimming, entering into the estimates of mica production as uncut mica.

*From 1910 to 1918 inclusive, the estimated annual average amount of ground and scrap mica consumed in the United States was 4401 short tons, the average annual production for the same period being 3774 short tons.

Classified as to its uses, the relative percentages of ground mica sold in the United States for various purposes in 1918 (the quantity sold being 50 per cent. in excess of the reported production), were as follows:

Patent roofing	60
Wall paper	21
Manufacture of automobile tires	8
Fancy paints, concrete facing, Christmas tree "snow"	3
Molded electric insulation	3
Annealing, filler for rubber goods (other than tires), printing lithography, sizing cotton, etc.	3
Lubrication, oils, greases and metal bearings	2
	100

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*U. S. Geological Survey Mica in 1918.

VALUE.

Statistical information relative to the value of the mica recovered necessarily bases upon an average valuation; which, owing to the wide range of the various grades produced, does not correctly reflect or indicate actual values.

As estimated and stated by the United States Geological Survey, the ratio in this country of finished trimmed sheets from the rough block varies widely, ranging from 2 to 33 per cent., a possibly fair average being 10 per cent. for such finished sheet recovery.

As in the making of official returns for the compilation of statistics, the various commercial grades of sheet mica, cut and uncut, run-of-mine, punch and washer, clear, and slightly stained, iron spotted, flawed and without defect; presenting the most extreme variations in market value, are very commonly lumped together, the incorrectness and unsatisfactory character of estimates based on average mica values necessarily so obtained is clearly evident.

Official figures of valuation compiled under the disadvantages stated, and ending with the year 1918, show that in that year as compared with ruling prices during 1917, prices realized were 27 per cent higher for punch; 38 per cent. higher for 1½ by 2 inches; 29 per cent. higher for 2 by 2 inches; 18 per cent. higher for 2 by 3 inches; 13 per cent higher for 3 by 3 inches; and 10 per cent. higher for larger sizes.

The average prices realized for sheet mica in 1918 on domestic output so comprehensively obtained and officially stated, was 45 cents per pound, but was materially influenced by the war basis of price fixing, effective by England in July, and by the United States War Board in October of that year, under the then existing war conditions.

The following table reflects prices ruling from 1913 to 1918 on the average return of valuation basis.

**Average prices per pound paid in the South for rough-trimmed sheet mica of good quality, split and sorted to cut the sizes indicated, 1913-1918.*

Size (in inches)	1913	1914	1915	1916	1917	1918
Punch	$ 0.035	$ 0.03	$ 0.04	$ 0.05	$ 0.055	$ 0.07
1½ by 2	.12	.10	.20	.30	.40	.55
2 by 2	.30	.25	.40	.55	.70	.90
2 by 3	.70	.65	.70	.90	1.10	1.30
3 by 3	1.15	1.00	1.00	1.35	1.55	1.75
3 by 4	1.35	1.20	1.25	1.70	1.85	2.05
3 by 5	1.70	1.50	1.50	1.95	2.15	2.45
4 by 6	2.25	2.00	2.10	2.85	3.10	3.45
6 by 6	3.00	2.70	2.80	3.50	3.80	3.90
6 by 8	4.00	3.60	3.50	5.00	4.70	6.00
8 by 10	6.00	5.40	5.20	7.50	7.50	8.00

*U. S. Geological Survey Mica in 1918.

The preceding table as noted above to some extent is influenced by war conditions and governmental price fixing. The continued post-war demand for mica by the electrical industries, has however not only maintained the higher level of war prices, but has even resulted in a material increase of these prices, extending to all grades, and amounting as estimated to approximately 25 per cent. or more for special grades most actively in demand. Analysis of these advances in value also indicates that they base largely upon the smaller sizes of mica, the most marked increase in prices paid per unit area, being for 2 by 3, and for 3 by 4 inch. As reflecting active preferential market conditions and demands for these smaller sizes, which must necessarily constitute the major part of the output of most if not all mica mines, these facts, if correctly understood and construed, are of material benefit and importance to the mica miner. Largely increased use of condenser mica also entered into these and present price advances. Among special war demands influencing 1918 prices the larges sizes, grades 1, 2, and 3 were required for spark plugs for the Aircraft Production Board, used in Liberty motors; grade 4 was specified for radio condensers, for both navy and signal corps radio apparatus; grade 5 being used for magneto condensers for the motor transport service, and the smallest size, 6, being also used for spark plugs.

Present market quotations as of date January 1921 which may be taken as an approximate index of the present values of the various grades, both foreign and domestic, when prepared in accordance with ruling market specifications ranged about as follows:

*India block mica, slightly stained, per pound, No. 6, 50 cents; No. 5, $1.20 @ $1.40; No. 4, $2.50 @ $3.00; No. 3, $3.50 @ $4.00; No. 2, $4.50 @ $6.00; No. 1, $5.50 @ $6.50. Clear block, No. 6, 50c; No. 5, $1.75; No. 4, $3.25; No. 3, $5.00; No. 2, $6.50; No. 1, $8.00; A1, $6.50 @ $8.50; extra large, $25.00; all f. o. b. New York. Ground $150.00 per ton Phila: Domestic uncut f. o. b. Franklin, North Carolina: scrap $45.00 to $50.00 per ton; punch 10 cents per pound; circle 15 to 25 cents; 1½ by 2 inch, 75 cents; 2 by 2 inch, $1.15; 2 by 3 inch, $1.65; 3 by 3 inch, $2.10; 3 by 4 inch, $2.50; 3 by 5 inch, $2.75; 3 by 6 inch, $3.75; ground 165 mesh, $150.00 to $170.00 per ton; ground roofing mica, $60.00; mica washers, 75 cents to $2.00 per pound. 1¼ inch disks: Number 1, $1.40; No. 2, $1.25 per pound. The foregoing domestic prices obtaining also in the Chicago district.

Prices paid for Alabama cut sheet local average grade, being spotted, and carrying some mineral inclusions were during the closing period of 1920 as follows: 1¼ by 5½ inches, per pound $3.50; 2 by 3, $2.50; 2⅛ by 4⅜, $2.50; 2½ by 3, $2.75; 2½ by 3½, $3.00; 3 by 3, $3.50; 3½ by 3½, $4.00; 1¼ by 5½, $3.50; 2⅝ by 5⅛, $4.10; 1½ by 8, $5.00.

IMPORTS AND EXPORTS.

The sheet mica including splittings imported for consumption in the United States during 1918, as reported by the Bureau of Foreign and Domestic Commerce, was valued at $1,539,482, the highest value recorded by the United States Geological Survey. In 1918 there were also imported 6 tons of ground mica valued at $1,647.

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*Engineering & Mining Record.

During the war years, imports of mica were received chiefly from England, Canada, India, Brazil and Argentina.

Exports mainly of manufactured products, were in 1918 as usually very widely distributed, being worldwide. During the year 1919, imports of crude mica showed an increase over 1918 of about 18 per cent. in amount and of over 20 per cent. in value, the stated increase being in part attributable to larger importations of the higher grades, as a decline of approximately 25 per cent. was noted in the value of cut mica importations for the same period.

Exports during the year 1919 were in excess of the amounts estimated as exported during the preceding year.

*During the first nine months of 1920, the mine industry in the United States was prosperous, but suffered severely from the general industrial decline during the last quarter of the year, which was marked by the falling off of market demands, and by unusual accumulations of surplus stocks, prices dropping in consequence from 10 to 20 per cent. in the various grades.

Importations of mica increased in 1920, reaching in the first ten months of the year 1,375,927 pounds of uncut mica, valued at $1,206,443, or nearly double that of the corresponding period of 1919. Cut mica was imported to the value of $1,656,182 in the same period.

Exports of mica during the first ten-month period of 1920, were valued at $243,381, about 10 per cent. of the value of imports.

The gradual resumption of industrial activity thus far during 1921, would not seem to indicate any possible increase of production during the present year, and it is doubtful whether the 1920 output will be at all equaled, the mica industry in North Carolina and in Georgia being at the present time virtually stagnated.

OCCURRENCE.

Mica deposits of commercial value or importance in Alabama and elsewhere, are located altogether in the

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*Prof. J. Volney Lewis in Engineering and Mining Record Annual Review Number, Jan. 22, 1921.

pegmatites, which are formations similar to granite in chemical and in mineral composition but coarser in texture, their aggregate, made up of quartz, feldspar, and mica; varying widely in the relative percentages of these constituent elements, as well as in the coarseness or fineness of their combination.

In the zone of weathering or within the limits of surface decomposition, the feldspar in the pegmatites has been in many localities either wholly or partially kaolinized.

The surrounding rocks, mainly of igneous and of metamorphic origin and probably of Archean age, are largely made up of the constituent elements; mica, garnet, cyanite, and hornblende, being commonly granite gneisses and schists, with occasional accompaniment or association also of the soapstones and serpentines.

The comparative regularity of the structural features of the enclosing gneisses and schists, to which in large measure the pegmatite lenses or bodies lie in conformity, tends to render them also more or less persistent in length along the strike, and often to considerable depth on the dip, although presenting wide irregularities in shape and form and variable in section as to width; tapering, widening and frequently as lenticular bodies overlapping. It is not uncommon to find them however as distinctly cross formations.

In the hornblendic areas, occurring at the extreme southwestern end of the Alabama mica field, the pegmatites are uniformly made up of a quartz and feldspar aggregate in small fragments or particles frequently carrying good flat muscovite mica of high grade, but generally speaking in sizes too small to be worth recovering, the mica occurring largely in the kaolinized feldspars.

Generally speaking, the irregular masses, lenses, streaks, and bodies, of pegmatite occurring in Alabama, present extreme variations in thickness, ranging from a few inches to fifty feet or more.

The quartz of the segregations is massive, usually granular, frequently crystalline, and uniformly persistent throughout the mass. Feldspar, usually either orthoclase or microcline, occurs in masses or distributed throughout the aggregate in variable amounts.

The occurrence or position of mica in the pegmatites also varies widely. In the granular masses, of finer texture, it is often quite uniformly distributed throughout the aggregate, and is therefore of small size although of good quality.

In the pegmatites of coarser texture, the mica crystals and masses are commonly found in concentration along the contact with either the foot or the hanging walls, partially plated or bedded on or in the wall rock, and collected around the edges of inclusions of horses, which are composed mainly of quartz, lying wholly within the pegmatite. Thin, and more than usually persistent bodies of pegmatite, schist-walled, giving them the appearance of veins, frequently carry highly concentrated mica inclusions, as is notably the case in certain deposits developed near Dadeville in Tallapoosa County, Alabama.

Horses, or wall-rock intrusions, are a very general and disturbing feature of practically all the pegmatite deposits of the State, complicating methods of mica mine recovery with attendant increase of mine cost. Their occurrence has a wide range of irregularity, both as to size or bulk, and in respect to conformity or non-conformity with the foot and hanging walls.

Mica, of what is commonly called A-form, or A-structure, is of frequent occurrence in Alabama as elsewhere, being usually found in masses, often of large size, but in such irregular shaped and distorted blocks as to be of small commercial value except for grinding, although small amounts of good flat sheet mica is to some extent recoverable near the centre of some of these blocks by splitting. Among mica miners, opinion varies widely as to whether or not a heavy surface capping of A-form mica may be taken as a reliable indication of an underlying deposit of flat mica, at a depth, and under conditions, favoring more perfect crystallization. As a matter of fact, variable amounts of good flat mica occur in the Alabama field coexistent with the A-form masses, and in some instances observed and studied, there is indicated a decided and possible change from A-form to altogether other and favorable forms of more perfect crystallization at greater depth, usually below water level. Masses however of mica of A-structure, in Clay County, Alabama, have in contradistinction, been taken out at a depth below water level, in direct association with considerable amounts of flat sheet mica of high grade. In close proximity to these variable deposits, following the well defined strike of apparently the same pegmatite leads, no A-form mica whatever occurs, and there has been recovered some of the finest and largest muscovite ever found in the United States, running in the lower entries of the mine up to sizes approximating 12 by 18 inches, of smooth flat sheet, almost wholly free from imperfections.

By reason of its marked resistance to ordinary weathering and resultant decomposition, mica is very generally of surface occurrence along the outcrops of pegmatite, enabling them to be readily traced up and developed. Decomposition of, or alteration in, mica crystals or blocks on or near the surface, however, varies somewhat, being governed by their hardness and associations. Thus open and clay-stained blocks, are commonly found extending to variable and often considerable depths under cultivated areas of long standing, while in or on outcrops of quartz, of pegmatite aggregates, crystals not infrequently occur, sound, unaltered, and free from imperfections, directly on the surface.

PROPERTIES AND CHARACTERISTICS.

In its application to the industries, mica, by reason of its more or less perfect cleavage, flexibility, elasticity, toughness, semi or perfect transparency, non-conductivity of heat and of electricity, and comparative resistance to decomposition, possesses qualities not shared by any other mineral product. The immense and constantly expanding growth of the electrical industry has been largely due to and dependent on the use of mica insulation, for which mica is indispensable and has no adequate substitute. Its necessary use in condensers, has recently been the means of radical changes and large economies in wireless telegraphy.

Muscovite has a specific gravity of 2.8 and is therefore heavier than its associations of quartz and feldspar.

In hardness, the various varieties and to some extent the same varieties of mica, vary somewhat, scaling in the Alabama field at approximately 2.5 or about that of copper, although frequently slightly softer. A close approximation in hardness to copper is material to the value of electrical mica in generators, as affording equal wear and the consequent absence of sparking in commutators of direct-current motors and dynamos, built up of copper bars and mica strips, for which purpose, and for the above stated reason, Canadian phlogopite receives the preference. The hardest mica recovered in Alabama is of the green variety of muscovite.

The structural characteristics and forms of mica are minutely and exhaustively described and illustrated in Bulletin 430-J of the United States Geological Survey by D. B. Sterritt and H. J. Gale, from which report, the following descriptions and explanations are literally quoted.

Muscovite, like all the micas, belongs to the monoclinic system of crystallization, and has a symmetry approximating the hexagonal. This symmetry is indicated by the nearly hexagonal outline often observed in the prisms by the percussion and pressure figures, and by "ruled" and "A" mica as described below. Mica mined for commercial purposes is generally found in rough blocks, sometimes with an irregular development of crystal faces. The faces are not usually as many as would be required to complete the simplest figure, and their surfaces are generally very rough. Very commonly a large part, if not all of a block of mica has a ragged outline without plane surfaces. Occasionally fairly well developed hexagonal or rhombic prisms are observed in crystals weighing hundreds of pounds.

Rough crystals, or "books" of mica as they are called in the Western States, do not split perfectly until the outer shell of etched and sometimes partly crushed mica has been removed. This is accomplished by rough splitting, or cleaving the large book into sheets one-eighth inch thick or less, and trimming the edges with a knife held at a small angle with the cleavage. Further splitting is then easy, because the cleavage of mica is so perfect and the tangled outside edges of the sheet have been removed. By grinding a wedge edge on the sheets and using a thin sharp knife, mica can be readily split into sheets as thin as one-thousandth of an inch or thinner.

As classified by physical peculiarities of crystalline structure, color, and inclusions, mica is commonly known to and spoken of by mica miners as "ruled" or "ribbon," "wedge," "A-form," "hair-lined," "fish bone," and "tangle-sheet." "Specked" or "clay-stained" mica, refers to mineral or clay inclusions in closed or open books. "Ruled" or "ribbon" mica, is formed by sharp parting planes cutting through the mica crystals at an approximate angle of 60 degrees with the base or cleavage surface, extending either through, or partially through, the crystal.

Ruling lines however usually occur in closely parallel formation, and while dividing the crystals into smaller, inconveniently shaped and less valuable and recoverable sizes, the grade of mica constituting the ruled portions, is quite uniformly good, constituting the best part of the crystal. No deposits of mica of any magnitude in the State have been examined which do not show ruled mica to greater or less degree, and in certain deposits it may be said to predominate. The physical term "wedge" mica, is of obvious meaning and refers to masses of varying thickness on the edges, due to unequal crystalline development.

A-form, or A-structure mica, called by miners "horsetail," carries a double series of lines or striations forming with each other an approximate angle of 60 degrees, from which characteristic its name is derived.

In "fish-bone" or "herring-bone" structures so-called, the striations form with each other an approximate angle of 120 degrees, meeting along the center line of the crystal.

"Tangle-sheet" is the trade and mining term used to describe mica in which the laminae are so formed as to split properly only in certain portions of the block, mainly around the edges. "Specked" mica contains inclusions of iron oxide or of other minerals with consequent reduction in grade and value. It is not of general occurrence in the Alabama mica field, but is found in some of the present operating mines.

In respect to color, muscovite is broadly termed "white" mica, although in the thin sheet it may present wide variations in shade, ranging from almost clear white to amber, yellow, green, brown and brownish-red, and darker red or "ruby."

Phlogopite, in the thin sheet, is of a yellowish or brownish color, deepening in the thicker sheet to yellow, brown, copper colored and verging on black. Color variations appear to be closely related to variations in hardness, elasticity, and dielectric quality.

In the matter of flexibility, a sheet of good muscovite a thousandth of an inch in thickness, should be capable of being bent into cylindrical form of ¼ inch diameter without evidence of cracking.

USES.

*The uses of mica may be summarized as follows, the classification being based on the physical property of greatest importance.

Electric insulation: Sheets, films, mica board, washers, mica cloth, and tape; for dynamos, condensers, telephones, light sockets, spark plugs, and innumerable other electric appliances. Ground mica, mixed with shellac, is molded into various insulating forms.

Heat insulation: Screens in front of highly heated material, as retarder of heat waves in optical lanterns, and in electrical heating devices. Ground mica is used as pipe and boiler coverings, in annealing steel, and in fire-proof paints and coverings.

Transparency: Glazing the fronts of stoves, for furnace sight holes, lamp chimneys, lamp shades, military lanterns, lantern slides, sight holes of diver's helmets, compass covers, gage fronts, in windows where glass would be broken by heavy shocks or vibrations, and as coverings for wounds.

Resonance: Phonograph diaphragms and various sounding devices (submarine detectors).

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*U. S. Geological Survey Mica in 1918.

Decoration: Sheets of mica form the material on which pictures and portraits are painted and for inlay work. Ground mica is used extensively for decoration in wall paper, processional ornaments, fancy paints, ornamental tiles, and concrete.

Lubrication: For wooden and metal bearings and for tire powder.

Filler: Patent roofing material, rubber goods, buttons, absorbent for nitro-glycerine, and various other products.

Miscellaneous: Calico printing, to prevent sticking of tar papers, medicinal uses (India only) etc.

*A recent classification of these uses of mica, based on their relative importance, is as follows:

Essential uses: Electrical insulation—films, sheets, washers, splittings, and built-up mica board.

Less essential uses: Stove front, lamp chimney and shades, electric heating devices, pipe and boiler coverings, roofing material, annealing steel, lubricant for wooden bearings.

Non-essential uses: Phonograph diaphragms, decoration, lubricant for metal bearings, filler for rubber and various materials.

Consumption of mica by the industries would largely base as to relative amounts, although not necessarily in respect to prices paid, on the above classification of uses.

Commercially speaking, splittings refer to sheets approximately about one thousandth of an inch in thickness, which thin sheets are manufactured by special processes into molded and built up forms variously known to the trade as micanite, micabeston, micabond, micademite and others, used extensively for electrical insulation.

Sheet mica finds its uses as above indicated in all three of the classes of essential, less essential and non-essential uses, and constitutes the most important and largest part of the mica industry. As commercially prepared, it ranges in sizes from what is known as punch mica, for the manufacture of disks and washers of at least 1½ inches in diameter, on up to the largest sheet recoverable with proportional values based on size, condition, and properties.

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*U. S. Bureau of Mines Mica in 1918.

The chief use and largest consumption of sheet mica is for electrical insulation. For use in high-potential machinery or appliances, only high-grade sheet mica, wholly free from imperfections in the form of cracks, pin-holes or inclusions is rigidly specified.

Originally, sheet mica found its principal and almost sole use in glazing, for stove windows and for certain forms of lamp chimneys. Although still necessarily in use for these purposes and commanding increasingly high prices for the grade and sizes of sheet required, the amount so used at the present time is hardly one-tenth of the sum total of consumption, which has been estimated to average: for electrical insulation, splittings, 40 per cent, and sheet 46 per cent., or a total for electrical insulation of 86 per cent.; stove glazing 10 per cent., phonograph diaphragms 2 per cent., the remaining 2 per cent. covering all other purposes.

The following table indicates, as to size, the various grades upon which market quotations usually base:

Trade Number	*Size in Sq. Inches.*
Extra Special	60 and up
A.A.	48 to 60
A1.	36 to 48
1.	24 to 36
2.	15 to 24
3.	10 to 15
4.	6 to 10
5.	3 to 6
6.	— to 3

During the late war, an entirely new use developed for sheet mica in surgery as a covering for open wounds under treatment, by reason of its transparency, its antiseptic quality, because of absolute freedom from corrosion, and its value as a non-conductor of heat and of cold, plates of mica being included to some extent in first aid kits used in the field.

Ground mica, aside from its former chief uses in patent roofing, in the annealing of steel, in various forms of lubrication and for fancy paints, tiles, and concretes, for boiler coverings and fire-proof paints, has recently developed increasingly a new application to the rubber-tire industry, as a tire ingredient, and as a powder for inner tubes. It has long been utilized as a powder to prevent adhesion in rolls of rubber belting, rubber or rubberoid roofing and similar materials. For use in the rubber-tire industry, new methods of grinding and of preparation were requisite in order to obtain the necessary fineness and freedom from any deleterious admixture.

Limited information only is available as to the methods little patented and largely kept secret, which have been so far most successful in producing the required rubber product. They mainly classify as first, disintegration by heating; second, abrasion with mill-stones or burrs; and third, by baking at intense heat followed by pulverization under a steam or air blast. Products ranging from 8 to 200 mesh are subsequently made after grinding, on vibrating screens. Ground mica so prepared, has been marketed at prices which have been found very satisfactory and profitable.

Should ground mica so prepared become a fairly universally used material as a filler in the rubber tire production of the United States, already estimated to have reached a figure in excess of 50 million tires per year, a very substantial increment in the value and use of what is now largely as scrap, a low priced or altogether waste product in mica production, is substantially indicated. While for this purpose it has been found superior to the filler hitherto in use, to which it has proved to be of more value and utility by reason of its special qualities, ground mica, for other and its ordinary uses, is the only form of mica for which a satisfactory substitute has been successfully found and commercially used. For electrical mica in its special forms there is no known substitute.

From its physical characteristics, the grinding of scrap mica or its first preliminary disintegration, is a difficult operation for reasons which are self-evident. Numberless methods have been tried, and where successful, have been as far as possible kept secret. The most satisfactory results have apparently been obtained by the use of various special forms of conical wooden rollers. The highest grades of "rubber mica," acceptably prepared under commercial specifications, are stated to have been marketed at prices ranging from $180.00 to as high as $300.00 per ton.

COMMERCIAL GRADES AND SPECIFICATIONS.

As known to the trade and the manufacturer, commercial mica is of three general classes designated as run-of-mine, sheet, and scrap.

Run-of-mine mica; as the name implies, refers to mica in its crude recovered condition, precisely as it comes from the mine, viz: in rough blocks or masses, with their rock edges adhering to them, and of all sizes and grades; their subsequent sheet values having not been as yet determined or being reliably indicated.

For this obvious reason, the prices offered and commonly paid for mine-run block are necessarily low, and do not as a rule represent a fair basis of compensation to the miner, as the skilled manufacturer, accustomed to working up such rough block, is better able to approximate its possibilities than any miner lacking this experience and knowledge. A very large percentage of the domestic mica mined both in the West and in the South, has in the past been disposed of on this basis, with resultant disadvantages and discouragement to the miner.

This condition, requiring only special knowledge and a reasonably small amount of necessary and added mine equipment for its abatement, has had a marked effect in limitation of mine output, many small operations having been abandoned in consequence of such low prices received which would have been otherwise remunerative. The reverse condition, is one of the causes of uniform success in the India mica field.

Sheet mica, as known to the trade; is defined and classified by its physical preparation and condition, and by its adaptability to its various uses and its value therefor.

The general trade definition of sheet mica refers to split sheets of approximately one-sixteenth inch in thickness, more or less properly trimmed or edged. By far the largest part of the domestic mica marketed, is improperly prepared, with resultant loss to the producer, being either "rough-trimmed," or "thumb-trimmed," and only partially edged.

"Thumb-trimmed" mica is the term used to describe mica blocks or books having the rock edging in part crudely removed by hand separation or breaking off. "Rough-trimmed" mica, represents a slightly better stage of preparation, and "knife-trimmed," its competent and proper form, all edging imperfections being removed, and the physical condition of the sheet for subsequent handling and shipment being as far as possible perfected.

*Sheet mica is also classified according to its uses. Condenser mica must be clear ruby, colorless or greenish, must be split easily and smoothly into films as thin as one-thousandth of an inch, must be free from cracks, holes, foreign substances, stains, spots, smoke, and sheets must be plain and smooth, free from waves, wrinkles, reeves, rulings, or knots. Uncut condenser mica, to cut any particular size, must not be larger than one and one-half times that size each way. Cut but not split condenser mica is cut into regular sizes, 2 by 2 or 2 by 3 inches, which are slightly larger than the thin sheet actually used in the condensers. From this cut mica the condenser film is then punched out in the shape and size used. If cut and split, the individual pieces are from 0.001 to 0.003 inch thick, with an allowable variation of only 0.0005 inch. If cut or punched into the required shape, split to the necessary thinness, and carefully inspected, the mica is called condenser film mica. The cut edges of the films must be smooth, and the finished film must of course be free from all defects and cracks. For wireless outfits, each film must withstand 20,000 volts. For magneto condensers, no high-voltage resisting test has to be made, but each film must be free from cracks or other defects. Such "film mica" is very different from the thin splittings used in the manufacture of mica board. These irregular-shaped splittings are sometimes also called films. It has been estimated that on an average it takes from 2 to 3 pounds of trimmed Indian or cut

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*U. S. Geological Survey Mica in 1918.

domestic mica (or double the quantity of uncut mica), to yield 1000 acceptable condenser films. By careful selection it has been possible to obtain a pound of cut films from 5 to 6 pounds of domestic uncut sheet mica.

Phonograph or diaphragm mica is also a variety of very high grade. It must be free from all imperfections, such as rulings, cracks, and inclusions of other minerals. must split well and evenly, must be clear and transparent, and must also be flat, this last feature being an essential character of diaphragm mica. Mica for lamp chimneys and canopies must be clear, split easily, and be extremely flexible. Very little domestic mica is so used.

For stove glazing, a hard rigid mica is preferred, as nearly clear as possible. The greenish North Carolina mica receives the preference for this purpose.

Splittings, commercially speaking, are very thin sheets, approximately one thousandth of an inch in thickness, may be irregular in shape and size, and may contain some flaws or imperfections. They are altogether prepared by hand, most of the large India preparation of splittings being made by women and children. a long thumb nail being there largely used in preference to a knife for this purpose. From 2 to 4 pounds per day of splittings represents an average production. A variable amount of domestic splittings accumulates necessarily in the working up of mine-run mica and in the general handling of cut and uncut sheet into specific forms.

The otherwise waste product of the mine in the form of mica recovered having no sheet value, and the waste resulting from the cutting. trimming and preparation of sheet mica, etc., collectively classes as scrap, which as sold and utilized for grinding may have, and usually contains inclusions of various kinds, mainly quartz and feldspar.

ASSOCIATIONS.

The useful associated minerals of the pegmatites in Alabama, of possible value as by-products, recovered necessarily in the ordinary course of mica mining, are kaolin, feldspar, and quartz; stated in the order of their ordinary commercial importance.

The feldspar group occurring with the mica deposits, mainly potash spars, with resultant kaolins are taken out to greater or less extent in all mica recoveries, but have received as yet in Alabama only limited tests and no appreciable commercial use. From 20 to 40 per cent. of ground feldspar enters into the composition of most china and porcelain, as a bonding and dissolving medium of the kaolin, ball clay, and ground flint. It has also a wide range of minor uses. As a source of potassium compounds, the potash spars received exhaustive testing during the war, the results of which tests have not yet been fully made known. It has been stated however that under present known methods a minimum of 12 per cent. of potash is requisite for any profitable process for its extraction from spar.

Such high grade feldspar is hardly likely to be obtainable in this State in any large centralized amounts. Analyses made of best native spars have averaged approximately 10 per cent. potash, although the samples tested would otherwise class as No. 1 by reason of freedom from iron bearing minerals, and as containing but little muscovite and quartz, an allowable 25 per cent. of quartz being permissible in No. 2 spar grade.

The most important and valuable use of this mineral would be its possible local value as ground feldspar for a commercial fertilizer. The availability of potash in finely ground feldspar has long been the subject of exhaustive practical tests, the results of which tests have been conflicting under varying soil conditions. Tests however under special conditions, made by the U. S. Bureau of Plant Industry, representing the wide variance of soils presented by Connecticut and Florida, have demonstrated that plants were able to obtain potash from very finely ground feldspar. If such availability becomes fairly assured through continued and systematic experimentation Alabama spars may become of very positive value.

Crystalline quartz, of certain specified grades, has various commercial uses. For acid towers, the sizes specified are termed "fist" to "head."

Ground quartz finds its application in the manufacture of sand-paper, sand belts, and in sand-blast apparatus for frosting glass. It is also one of the constituents with feldspar and kaolin of pottery and glaze mixtures. In copper smelting, it is used as a flux. Finely ground it finds its application to some extent for filters, and in acid proof cements; as a wood filler, and in scouring and cleaning preparations, and paints.

The commercial value of the crude product ranges from 80 cents to $3.50 per ton, and from $6.50 to $20.00 per ton for ground quartz of various degrees of fineness.

The kaolins, resulting from the decomposition of the potash spars in the mica bearing pegmatites, constitute a very considerable part of the dead material necessarily removed in the recovery of mica. Competent expert tests made at Trenton, New Jersey potteries on certain Alabama kaolins occurring in the mica pegmatites, have proved them to be of superior quality for use in porcelain manufacture. A detailed statement of these tests, and of the values indicated, will be found under the head of kaolin.

The above facts relative to the uses and approximate commercial values of the pegmatite minerals other than mica, are given as of possible and material bearing on the question of by-product recovery in mica mine operation; being an available means of possibly reducing mine cost by their utilization.

Statistics of recently augmented mica output, have clearly indicated that by-product recovery has been to a considerable extent an important and increasing factor in such augmented production. Hydro-electric power is now in the Alabama mica field at certain points available and will in the near future become increasingly so for economically grinding scrap as also the above named mica by-products requiring pulverization into acceptable and salable commercial forms and grades.

As a positive mineral value, directly and indirectly associated with the mica pegmatites of Alabama, gold may prove of material and definite importance.

The original exploitation of mica in this State and its first attempted commercial development, was located at

Pinetucky in Randolph County, where in the early "seventies" a number of shafts and tunnels were opened up on this property, and considerable amounts of mica of large sizes were recovered and sold. It was however discovered by the operators that the quartz of the pegmatites was frequently rich in gold, and the mica recovery became secondary to gold mining, later on being altogether abandoned in favor of mine and mill recovery of the gold values carried in this mica mine.

During the subsequent period of such operation by the Alabama Gold Belt Mining Company, the Pinetucky mine was in 1897 examined by Mr. W. M. Brewer, then Assistant Geologist of the Alabama Geological Survey, who reported very rich free gold occurrences on the fifty-five foot level. Assays of gold-bearing quartz from the Pinetucky mine are stated by Mr. Brewer to have frequently run in free gold, irrespective of the sulphurets, from $150.C0 to $200.00 per ton. In this immediate district, which is now receiving extensive mica development, it is stated by Mr. Sam Wallace, the present owner of the Pinetucky mine and mill, that the quartz of the mica pegmatites very generally carries free milling gold values, which may to some extent be economically recoverable as the district develops, the formation of a natural water power closely adjacent for the operation of stamp mills being among the possible development factors. A more detailed description of the Pinetucky Mica Mine will be found under the heading of individual mine operations.

An occurrence of tin in the form of cassiterite has also been noted by occasional float ore at various points along the Mica Belt. No systematic attempts have, however, been as yet made to trace this ore to origin, and it is hardly likely to occur in commercially recoverable amount. Water worn float of white cassiterite, of the highest grade, has been also occasionally found and noted in close proximity to the mica bearing pegmatites.

DISTRIBUTION OF DEPOSITS.

The occurrences of mica of possible commercial importance in Alabama are comprised altogether within the lines of demarkation of the igneous and metamorphic rocks, as shown on the Geological Map of Alabama by Eugene Allen Smith, State Geologist, issued by the Geological Survey of Alabama in 1904. The lines of demarkation referred to and so drawn on this map by Dr. Smith will serve to define and mark out the mica area of the State. Comprised within this area, are all or portions of ten counties, which in the order of their present partially proven and relative importance, are Randolph, Clay. Tallapoosa, Coosa, Cleburne, Chambers, Elmore, Talladega and Lee. The mica pegmatite occurrences are comprised within a number of parallel belts of general northeast to southwest strike, entering Alabama along the Georgia state line, and terminating at various points along the areal limit of the igneous and metamorphic formations. Topographically, the eastern half of the area is traversed from northeast to southwest almost centrally by the Tallapoosa River, the western half being intersected and approximately bordered by the Coosa River, on which included portion of the Coosa is located the present main hydro-electric power plant of the Alabama Power Company, and also the location of the new power plant at the Mitchell Dam now in process of construction in Section 15, Township 21 South, Range 16 East, Coosa-Chilton counties. By these two rivers and their tributaries, the entire area is drained and abundantly watered.

The mica deposits lie at various elevations, ranging from 500 to 1,000 feet above sea level. Some are located upon summits or abrupt slopes, others on plateau or former plateau, and on valley levels and slopes, for the most part carrying fairly light over burden of residual clays. Favorable conditions as to mine drainage are often presented, although in many cases, water level is quickly reached and has presented discouragements. In some of the best and most fully developed deposits however, ideal drainage conditions are available. The level of the ground water encountered necessarily varies widely.

The quality and character of the mica recovered varies in different localities, the variations presented being connected with or attributable to the geologic conditions existing, as for instance proximity to the granites.

Generally speaking, the micas of the same locality and origin are similar and present few differences in characteristics. There are however exceptions to this rule, as in Tallapoosa county, where clear amber muscovite is recovered in close proximity to deposits largely made up of specked and spotted mica, carrying mineral inclusions. It is a notable fact, however, in this connection, that sales made of this particular spotted mica for electrical purposes are stated to have been apparently unaffected by these inclusions, which were not materially reflected in the sale grades and prices realized therefor.

Considered in respect to maximum and definite development, the Alabama mica occurrences might be divided into four major combinations designated as the Dadeville, the Micaville, the Pyriton, and the Rockford groups. As however this group subdivision is of complete occurrence separately in four counties, it will be considered under the general heading of all occurrences in each county.

PART II.

DESCRIPTION OF MINES.

INTRODUCTION.

MICA, in more or less clear sheets, and to some extent of merchantable quality, has been found in every county lying within the crystalline area of Alabama.

Comparatively little actual mining worthy of the name has however as yet been attempted, taking into consideration the possible extent and value of the indicated deposits, such recoveries as have been attempted being largely inexperienced, with limited knowledge therefore of the ordinary peculiarities and characteristics governing mica occurrences; handicapped by insufficient equipment, crude as to methods employed, and quite universally abandoned at water level.

Although the output of some of these mines has been large, and continuously satisfactory, with few exceptions there has been no competent effort made to grade and prepare the accumulated mica stocks recovered in such form as to realize or in fact approximate their actual market value if prepared in accordance with ruling market conditions and specifications. Generally speaking, these stocks have in consequence been disposed of on the run-of-mine basis at low and unprofitable prices.

With practically no scrap or by-product utilization; the earnings of the mines most of them wholly basing in consequence upon some three to ten, or at most, fifteen per cent. of their actual gross tonnage output, and under the crude and unnecessarily costly methods of recovery used, the frequently unprofitable character of the mica industry in Alabama up to the present time is quite easily understandable, and to a very considerable extent, is clearly remediable.

The future successful operation of these mines upon any permanent basis will in large measure depend, (as has been found to be the case elsewhere), upon the proper handling and utilization of the scrap mica, kaolin, feldspar, quartz, and other by-product recoveries, usually to a large extent wasted, or thrown on the dump, as well as on the experienced grading and working up of the sheet mica into the proper merchantable form requisite for the accumulation of graded stocks, which may then be disposed of at more satisfactory and remunerative prices to the manufacturer, and to some extent, more directly to the ultimate consumer.

Under competent, experienced, and intelligent mining and marketing methods, and provided with reasonable and justifiable mine and shop equipment, requiring a comparatively small invested capital, financially satisfactory returns are indicated as entirely possible and probable from most of the larger mine operations, and from the majority of the smaller ones as well, by the operation of a developed system of pooling by the smaller with the larger mines of their recovered and prepared sheet, for the enlarged accumulation in this manner of a properly graded joint stock, of sufficient extent, size, and range, to fill orders for the special sizes and shapes always required by the trade; this stock to be disposed of under a combined sales system.

In the same manner, and under a similar system, groups of mica operations, large and small, located in sufficiently close proximity (of which there are a number in the State) could in some instances combine their output of scrap, operating centrally located grinding plants for the utilization of this scrap, and possibly also to some extent of other by-products requiring crushing or some form of pulverization.

Auxiliary to such utilization of mine scrap, there are, (as will be hereinafter noted) a very considerable number of mica deposits located centrally with respect to the workable sheet mica mines, yielding mica suitable only for grinding, but affording definite amounts of this grade, so conditioned as to be recoverable at low cost.

The resultant ground mica from these deposits has been experimentally shown to be equal in grade to any other ground mica commercially marketed, under developed and proven methods of competent preparation.

There are indicated in this wholly undeveloped branch of the industry, some opportunities in the Alabama mica field for profitable investment.

In this connection, local conditions, as to hydro-electric leased power (already available at favorable rates over the existing transmission lines of the Alabama Power Company or by short branch lines) for the partial elimination of present mine waste by by-product utilization, and for the auxiliary handling of strictly grinding deposits, will become apparent from a study of present individual mine operations, solely based thus far as stated upon the realized small percentage recovery of strictly run-of-mine sheet.

With 120,000 H. P. already available, 120,000 H. P. under construction at Mitchell Dam, and an indicated as definite prospect in view in excess of 500,000 H. P. more by the completion of the projected power plant at Muscle Shoals, any Alabama industry of this nature will be able to estimate on hydro-electric leased power, in any desired amount, at a figure of cost equal to and in future probably less, than the present Niagara Falls basis.

The specimens and samples mentioned and referred to by "Exhibit Serial Numbers," representing all mine products of present or of possible commercial importance drawn from the localities and mines examined, have been collected for permanent display in the cabinets of the Alabama Geological Survey and placed there for public inspection and study in connection with this report.

TALLAPOOSA COUNTY.

The county, for the most part comprised within the Piedmont Plateau province, only a small portion of its southern area lying within the Coastal Plain region; presents therefore in surface conformation, characteristic variations, ranging from the flat uneroded Coastal Plain, to the hilly and much eroded and broken contours of its northern or Piedmont section, which section topographically, contains and is made up of hills and ridges having elevations of from 500 to 750 feet above sea level, and from one to two hundred feet above adjacent valley levels.

The Piedmont irregularities of contour generally speaking have their origin in denudation, the marked irregularities observable in the dip of the rocks showing crustal movements of wide extent. In the comparatively flat or rolling conformation of the southern part of the county, former irregularities of surface have been largely covered by Coastal Plain deposits, extending in some localities to considerable depth.

The Tallapoosa River, which flows through the county from northeast to southwest for a distance of some 75 miles, constitutes with its tributaries, the complete drainage system of the entire area.

This mature and favorable drainage system is a development factor of very great present and potential value to the county as a source of hydro-electric power, locally developed.

Dadeville, the county seat, is already supplied with light and power from a plant located on Sandy Creek. Alexander City, at present served by the transmission lines of the Alabama Power Company, could develop its own power if desirable near by on Big Hillabee Creek.

At Tallassee, in the southern end of the county, sufficient power has been developed on the Tallapoosa River and already utilized for the operation of a group of cotton mills, with available surplus.

Two miles north of Tallassee, also on the Tallapoosa, a forty-five foot head has been developed and a power plant erected, from which several thousand horse power is at present conveyed by a transmission line to Montgomery.*

In addition to these existing hydro-electric developments, there are other localities both on the Tallapoosa and on the smaller streams where added potential power in greater or less amounts may, and doubtless ultimately will, be produced and utilized locally in this county.

MICA DEVELOPMENTS.

Columbus Ware Mine, or "Mica Hill."—Recent active mica mining operations in the county have been largely confined to the six properties owned by the Coosa County Mining Company of Wetumpka, Ala., of which properties Mica Hill has been the major operation. It is located in the Southwest Quarter of the Southwest Quarter of Section 7, Township 22 North, Range 24 East, being about six miles northeast of Dadeville, near Easton, and about one quarter mile south of the main road known as the Montgomery Highway.

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*This source of power is not available at present by reason of the failure of the dam some eighteen months ago. E. A. S.

Topographically, the mine occupies the crest of a hill forming one of the highest points in the county, having an elevation of approximately 850 feet, tidal datum, and a rise of about 100 feet above adjoining valley level.

In conformation, the summit of the hill is cruciform, with the easterly arm eroded or lacking, the pegmatite bodies being similarly cross formed, and approximately occupying both axes of the hill. The country rock is a reddish mica gneiss, the pegmatite contact with which is somewhat irregular. Large masses of barren quartz outcrop on the summit along the northwest-southeast bone or axis of the hill, dividing and separating the two distinct pegmatite bodies, which as developed, for a distance of some five to six hundred feet, have a general southwest dip varying on the slopes and shafts driven, from 35° to perpendicular. On and near the surface, the two pegmatite bodies appear to be some 50 feet apart, separated by a massive V-shaped quartz intrusion, approaching each other rapidly at the lower levels reached, their ultimate union at lower levels being indicated.

For purposes of identification and description, the easterly body of pegmatite has been known as the "punch vein." It was originally entered and worked by open cuts along its extension on the surface for some 500 feet. Subsequently, three slopes, located about 100 feet apart, have been driven down following the pegmatite seam for varying distances, the main and most northerly of these slopes being carried down to a connection with a vertical shaft, located in the westerly pegmatite body used as an air course. From this main slope, which was operated by means of a hoist, entries were run out at various levels north and south in the mica bearing pegmatite.

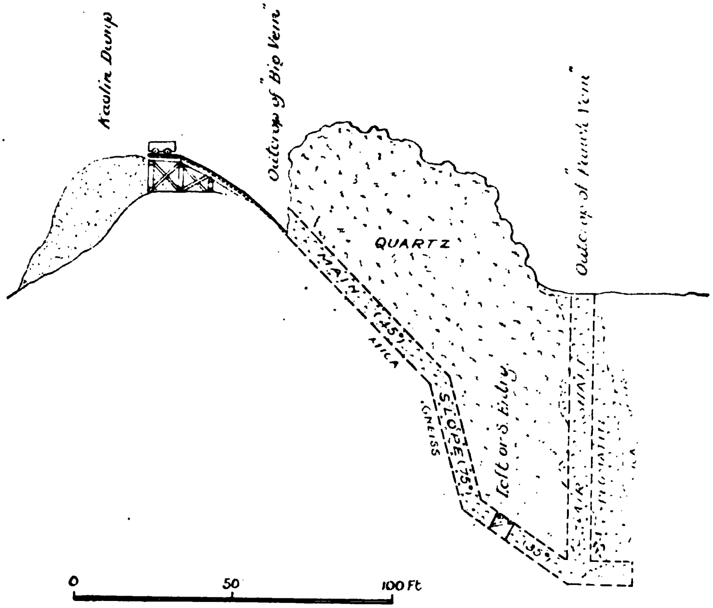

Figure 1.
CROSS SECTION of MAIN SLOPE
MICA HILL MINE
S 7 T 22 N. R 24 E.

Operation of this slope was complicated and subsequently abandoned by reason of the broken-back angles in the dip of the pegmatite, which for the first 70 feet was 45°, changing at this level to 75° for the next 40 feet, where it flattened out to 35°, at or near the bottom of the air shaft.

At the time the mine was last examined, this slope had been abandoned and could not be entered. The hanging wall at its mouth, is the intrusive quartz body, which was continuously followed and undercut all the way down.

Subsequently, and more recently, the two other slopes mentioned, known as the "Hand", and the "Smith" slopes, were similarly driven to a depth of approximately 80 feet, entries and stopes being run out north and south therefrom. These two slopes have also since been abandoned, present mine recovery being by means of a shaft driven on the westerly or so-called "Big Vein," from which working shaft, at the 61 foot level, a horizontal entry has been run out east 35 feet, thence striking and following for some 30 feet the 75° uprise along the foot wall of the "Punch Vein."

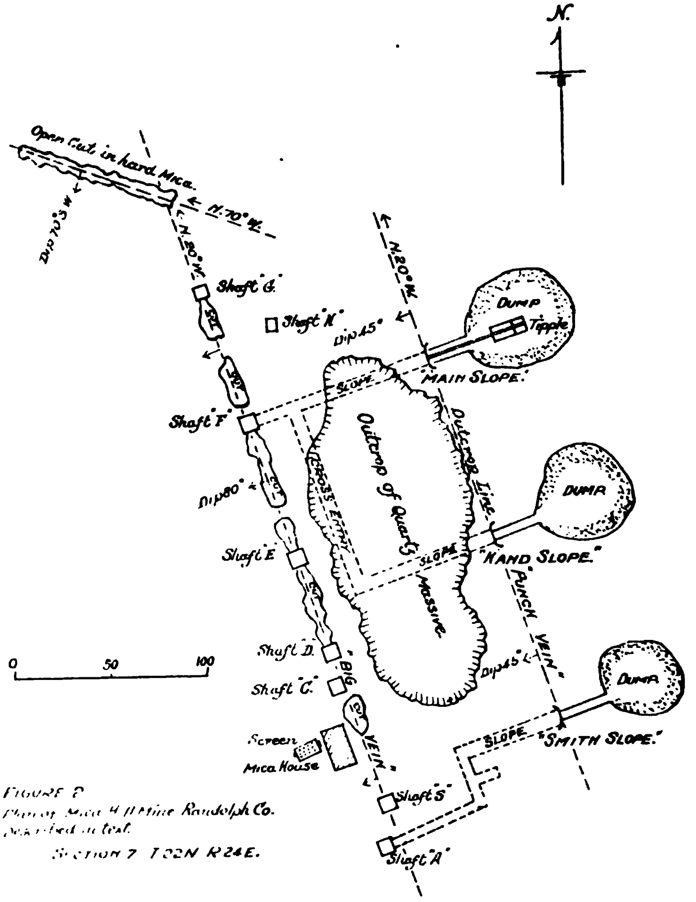

FIGURE 8
Plan of Mica [illegible] Mine Randolph Co.
described in text.
Section 7 T22N R24E.

At the head of the uprise, a north entry leads out horizontally along this foot wall about 40 feet, to the present working heading or breast, from which point a narrow and irregular entry continues on north to a connection with the "Smith Slope" for an air course. As stated by the superintendent, Mr. Dave Norris, the ultimate purpose of this working plan was to stope on up to the surface for a resultant slope recovery, but at the time the examination was made all the entries from the shaft out had been so back filled temporarily with kaolin and mine waste, as to be almost impossible of access, the cost of mica recovery by such means and under such disadvantages being largely prohibitive.

The westerly pegmatite body, known as the "Big Vein," lies parallel to the "Punch Vein," having a strike of N. 20°W., and has been similarly developed along its surface outcrop by open cuts for about the same distance. Mica recoveries have been made from this "vein" by these open cuts, and by six shafts located as shown on Figure 2. varying in depth from 30 to 65 feet. The pegmatite body here entered, has a very slight S. W. dip standing nearly vertical.

Most of the original mica mining on this property was done on the "Big Vein," from which at various times and under previous ownership, mica in excess of 100 tons is stated to have been recovered and sold, running above general average in the percentage of sheet.

Practically all of the sheet mica obtained from this mine has been taken from the contact, next to the foot wall, and the continuance of this rule of occurrence was an observed and noted fact in all of the slopes and entries examined. No mica of large size has ever been found in the kaolin, which, however, carries in excess of 50 per cent. of small flake.

In the "Big Vein," the micaized portion of the pegmatite has an observed average thickness of from one to four feet, and in the "Punch Vein," of from 6 inches to 2½ feet; within which limits all of the mica of value as sheet is carried or comprised.

Outside of the micaized portions, the pegmatite bodies present the usual variations as to thickness, but are continuously persistent and never lenticular along the strike throughout the mine as thus far worked.

Owing to the elevation at which the deposits are placed and have been entered, water level has never been as yet reached in any of the shafts or workings. The feldspar of the pegmatites has been to the depth reached almost altogether kaolinized, the resultant clay carrying a heavy percentage of very fine flake mica. Considerably over 1,000 tons of this kaolin are already piled up in the various mine dumps which if washed and freed from mica

PLATE I.—MICA HILL MINE—KAOLIN DUMP.

and other impurities could probably be profitably sold. Samples of fresh run-of-mine kaolin were recently submitted to Trenton potteries, and were so favorably considered that a sample carload was subsequently ordered and is now being worked up at Trenton.

At the northerly end of its proven extension, the "Big Vein" is intersected by an unusual formation of hard mica forming an angle with it of 50°, or having a strike of N.70°W. This cross formation or intersecting mica body, has been opened up by a surface cut for a distance of 90 feet along its N. W. strike from the "Big Vein," and is traceable by outcrops for an additional distance in the same direction of some four or five hundred feet, under apparently similarly micaized conditions. As opened up and developed in the cut to a depth of five to ten feet, it has a width or thickness of about eight feet, and an observed dip S. W. of 70 to 75 degrees, both foot and hanging walls being red mica gneiss.

The mineralization varies from a hard form of A mica, to a mica schist made up of flake of all sizes, which as a rule, appears to be nearly all mica. Some 50 to 80 tons of this schist have been taken out of the cut and piled up along its sides. Very little quartz or any other form of inclusions appears to be present. A few of the lumps taken out carry a thin plating of botryoidal manganese.

As a source of ground mica, this deposit has distinct possibilities, if found after proper tests to be of acceptable quality, definite amounts of the above described grade being indicated as recoverable to some extent by economic open cut mining, and by subsequent underground methods, with a possible expectancy of alteration to other and better grades at lower levels.

A second occurrence of this same character is indicated by outcrops, striking approximately parallel to it, and located some 70 yards further south, following and underlying the crest of the westerly arm of the hill, and traceable for several hundred feet to the point where the ridge breaks down.

No attempt has been made to prospect this deposit, but if found to be of equal extent and similarly conditioned to the northerly cross formation, the two deposits, in combination with the normal scrap output of the mine should justify a grinding plant of the minimum unit size taken in conjunction with the scrap recovered from other existing mines in the immediate district which would be available.

Since its acquirement by the present operating company, about 150 tons of mica in all have been recovered and sold from the Mica Hill mine. During the last period of operation, covering about ten weeks, working only a very small force, and recovering the mica by the crude and inefficient methods above described involving handling and rehandling in the mine, there was nevertheless taken out about 5,800 pounds of sheet, and approximately 60,000 pounds of scrap, 13,000 pounds of the scrap being partially cleaned by running it through a reel.

Of the approximately 9 per cent. of run-of-mine sheet mica recovered, about 3 to 4 per cent. of cut sheet appears to have been the net result in recent operations. The sheet mica taken out, is an amber muscovite of fair size, splitting well, and averaging about 3x3 inches in size. No larger mica has been as yet recovered in appreciable amounts.

It carries some inclusions and is uniformly more or less spotted, but has been sold as electric mica without rejection on this account being generally flat sheet, fairly free from other imperfections.

Exhibit samples, serial numbers 100 to 104 inclusive represent the mine products.

Carleton or Buttston Mine.—The Carleton mine belongs also to and has been operated by the Coosa County Mica Company. It is located in the S. E. Quarter of Section 22, Township 23 N., Range 24 E., being about 11 miles northeast of Dadeville, and about one-quarter mile south of Tallapoosa River, east of, and near, Germany Ferry.

The deposit of mica developed and mined is located in a low flat hill, lying between two branches of County Line Creek, having a summit elevation of 40 feet above creek level.

The mica recovered has been altogether of A form, hard and non-sheeting, suitable only for grinding. It is carried in irregular lenses and seams of coarse pegmatite, which have no definite formation, being interbedded with crystalline quartz in large bodies and with both a white and yellowish feldspar, partially kaolinized near the surface, and but little altered or decomposed near the bottom of the cuts.

An irregular shaped area, about 200 feet wide from east to west, by 150 feet from north to south, running from the westerly arm of the creek to the summit of the hill, has been worked over by irregular pits and excavations, following up the various mica bodies found to be located along and occupying the fissures between the enclosing quartz and masses of mainly undecomposed feldspar, none of these workings having been carried to a depth of over 10 feet.

Within this area, and to a depth of from 5 to 10 feet, approximately 175 tons of A form mica, mainly in blocks of considerable size, is stated to have been recovered and sold as scrap during 1920.

Prices realized for it crude, with the attendant long truck haul to Dadeville, the shipping point, did not at the time justify deeper or more comprehensive methods of recovery, and the operation was in consequence for the time being abandoned.

Exhibit samples, serial Nos. 105-106, were drawn to represent the character of this deposit.

Berry Mine.—The Berry mine is located at Easton, in the N. W. ¼ of the S. E. ¼, of Section 12., Township 22 N., Range 23 E., being ½ mile N. W. of Mica Hill, immediately south of the Montgomery Highway, and within a few yards of it.

The mine is also the property of the Coosa County Mica Company, but has not been recently operated.

Under previous ownership, and when at that time examined it had been opened up by means of several shafts driven to water level, from which a considerable amount of clear sheet mica of satisfactory grade was being taken out and sold.

The characteristics of the pegmatite body entered were a predominance of kaolin in which the mica was altogether carried.

Mine recovery was much complicated and finally abandoned by reason of the unsafe character of the schist hanging wall, containing mud slips near the surface.

When recently examined the shafts had caved in and the mine could not be entered.

Abernathy Mine.—The Abernathy mine is located in the E. ½ of the N. E. ¼, of Section 7, Township 22 N., Range 24 E, near Easton.

The mine is a new prospect just opened up, and is located about 60 yards north of the Montgomery Highway, in a low flat hill.

Developments consisted of several small pits and a shaft about 10 feet in depth, from the bottom of which an entry had been run out into a bed of micaized kaolin, more or less intermixed with surface residual red clay.

The deposit had not been sufficiently prospected to form any definite idea either of its extent or character. About 2 tons of mica had been taken out, mainly in driving the entry, and was piled up on the bank, mainly consisting of small books, averaging in size about two by three inches, and of the grade to be expected under existing surface conditions, containing specks or inclusions, and somewhat folded and flawed. The mine is the property of the Coosa County Mica Company.

Exhibit sample, serial No. 107, represents the recovered product.

J. I. Easterwood Mine.—The Easterwood mine is located in Section 8, Township 22 N., Range 24 E., being 1¾ miles east of Easton.

Present mine workings are located near and on both sides of the Montgomery Highway. The deposit was originally entered by five old shafts located about 40 yards south of the road, from the bottom of which shafts stopes and entries were run out under a formation of white quartz boldly outcropping on the surface about centrally of the old workings. Very little information was obtainable as to the history of these old workings which could not be entered for examination, but a considerable amount of good flat mica, in medium sizes, is said to have been recovered from them by a Mr. Hamby and others. Preparations were being made to reopen them at the time of the examination by sinking a new working shaft.

About 50 feet N. of the road, a new working shaft had been sunk 20 feet in depth, from the bottom of which an entry had been run out S. E. on a slope of about 10° in a body of grayish colored kaolin, much intermixed with small angular fragments of quartz and unaltered feldspar. From this stope, about 4,000 pounds of mica had been recently taken out by present operators, a portion of which stock was examined. The recovered mica is a muscovite of dark rum color, flat, free from specks or inclusions, running in sizes from punch to about 3x4 inches.

Exhibit sample, serial No. 108, represents the average mica last recovered.

Small surface prospect pits are observable at various points for several miles along and near the Montgomery Highway, following the N. E. strike of the pegmatite occurrences opened at Mica Hill, from which openings small quantities of mica have been at various times recovered by farmers owning the properties, and generally disposed of to the Coosa County Mica Co.

Saunders Pit.—In Section 3, Township 22 N., Range 24 E, 1½ miles S. of Buttston, on the Saunders property, a small prospect pit has been opened up some 200 yards W. of the road, in which a greenish muscovite mica was discovered, a small amount of which had been taken out.

Exhibit sample, serial No. 109, is from this pit.

Thomas Mine.—Southwest from Mica Hill, although the continuance of the micaized pegmatites is occasionally indicated by surface outcrops, there has been very little exploiting done and no mines or prospects were ascertained to have been opened up, except one located on the C. W. Thomas property, about 6 miles S. W. from Dadeville. The Thomas mine was not examined, but is stated to have been worked intermittently during 1920 and the output sold to the Coosa County Mining Co. Examination of the stock so disposed of and on hand shows it to be a muscovite of very light rum color, practically colorless in the thin sheet, containing no inclusions, and running in sizes up to 4x6 inches.

Exhibit sample, serial No. 110, is from this stock and representative of the Thomas mine.

RANDOLPH COUNTY.

Physiographically, Randolph County lies in one of the most southerly sections of the Piedmont Plateau.

Geologically, it is an eroded plateau of extensive and strongly marked weathering and erosion, the underlying rocks being of igneous and metamorphic origin.

The mica bearing section of the county is mainly, if not altogether, comprised within its western half, being areally carried in a belt or zone of northeast to southwest extension across it from the Georgia state line to Clay County.

The prevailing rocks of the micaized zone are mica and hornblende schists, gneiss, and granite with their intergradations. The general N.E.-S.W. strike of the measures, carries, and is subject to, frequent marked and wide local variations, due to extensive folding and contortions.

Intrusions and interstratifications of quartz veins are of general occurrence as also less frequently of hornblende, and occasionally of chlorite, schists.

Topographically, the mica deposits developed are located mainly in the hilly to mountainous section of the northerly watershed or divide, at an elevation, tidal datum, of 800 to 1200 feet, and approximately 100 to 200 feet above neighboring valley or stream level. So located, the mica bearing pegmatites largely outcrop, resultant kaolin deposits carry light over-burden of residual soil, and mining operations are frequently facilitated by favorable mine drainage, and by the more than ordinarily lower level of surface water.

As previously stated, the first attempted recovery of mica commercially in Alabama, was made in Randolph county near Micaville, in what was subsequently known as the old Pinetucky gold mine, probably about the year 1870.

Mica occurrences in that locality being more clearly marked on the surface and of wider extent than at any other point in Alabama, more resultant development and actual mica mining has been in consequence intermittently carried on there than at any other point in the State, the vicinity of Pinetucky, and of Micaville, being at the present time still the center of greatest activity. Some six or eight new companies have been recently incorporated, owning and operating mines in the Micaville-Pinetucky group.

A potential factor in this local mica development, of possible and material future importance, although not as yet taken into consideration as any definite feature of present mine operations, is the clearly proven existence there of large deposits of china clay, suitable for porcelain manufacture, which are carried in the mica bearing pegmatite and are as yet only a waste product. Attention was called to this fine porcelain clay by Tuomey* as far back as 1855, and convincing tests were made of them later by the Alabama Kaolin Company, at Trenton, New Jersey potteries, in 1889.

Arnott Mica Mine.—The Arnott Mica Mine, belonging to and at present operated by the Minot Mica Company, of Minot, South Dakota, is located in the S. W. 1/4, of the N. E. 1/4, of Section 2, Township 18 S., Range 10 E., about 1 1/2 miles W. of Micaville, and 1/4 mile S. of the Cleburne County line.

The body of pegmatite developed in this mine has a clearly defined strike of N. 20° E., and a regular dip of 45° S. E. It is traceable by surface outcrops for a distance of 300 feet or more N. E., and nearly the same distance S. W., from the main shaft.

The mine is located in a low flat hill or ridge, having a summit elevation of about 50 feet above the run of the branch or small creek east of the hill. In respect to development, this mine is one of the few mica deposits in the State which have been competently opened up in accordance with ordinary and customary mining methods, based upon an expectancy of and due consideration for, reasonably permanent and economical mine recovery.

Original development was initially made by the present shaft, 15 feet in depth, located on the outcrop, from the bottom of which shaft a slope was driven, following and lying in the pegmatite, which proving to be continuously micaized and extensive, justified the subsequent and proper method of entry by the present tunnel, run in from the base of the hill. An open entry cut 80 feet in length reaches the portal of the tunnel, which in a further length of 80 feet intersects the pegmatite body at the foot of the slope, affording proper ventilation and facilities for economic mica recovery.

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*Second Biennial Report of the Geology of Alabama by M. Tuomey. 1855.

Right and left entries from the slope have been driven on three levels, connected at intervals by stopes, leaving proper intermediate roof support, and effectively blocking out the ore as is shown in Figure 3, a plan of the mine workings.

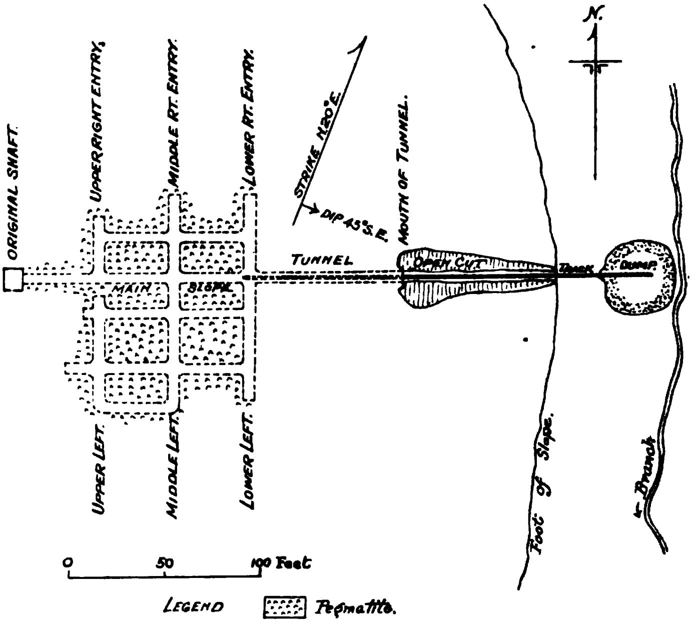

FIGURE 3 Plan of the mine workings of the Arnold Mica Mine Randolph County. described in text
SECTION 2 T18S R.10E.

At the tunnel level, the lower right entry extends 40 feet N., and the lower left entry, 60 feet S. Ten feet higher vertically, the middle right entry has been driven 40 feet N., and the corresponding left entry 60 feet S., connection between the first and second working levels being by means of the three stopes shown on the plan. The third or upper working level, located 10 feet higher than the second or middle level, and about 6 feet below the bottom of the vertical shaft, is opened up by means of a 30 foot right or N. entry. The south workings on this level are reached by three stopes from the second or middle level, and have not been as yet run out N. to a connection with the main E.-W. slope. On this left or S. entry two working stopes, or rooms, have been driven above it ten feet in length.

The pegmatite deposit having been found to be narrowing in the N. entries to finally about 3 feet or less, and correspondingly widening in the S. entries to a final width of 10 to 12 feet or more, the N. entries were temporarily abandoned, and most recent recoveries made altogether from the south side of the mine. All indications observable, both on the surface and in the mine, point to a definite continuance of the pegmatite body S. beyond the present mine limits, with favorable micaization. From surface outcrops it is indicated also that its extension N. may be possibly lenticular, and quite likely to widen out in that direction beyond present mine limits, or to prove of side displacement possibly overlapping. The narrowing or pinching observed in the N. entries is apparently caused by a rise in the foot wall.

The prevailing characteristics of the pegmatite body entered are a coarse aggregate, containing quartz intrusions in mass formation, walled uniformly top and bottom by a reddish mica gneiss. An unusual condition observed as compared with other mines in this immediate locality, is the occurrence of the mica generally, and more especially the larger crystals recovered, imbedded in and on the mica gneiss, along both the upper and the lower contact, and in but few instances in or on the quartz. This has been, according to the superintendent, Mr. John Arnott, the quite uniform method of occurrence. The peg-

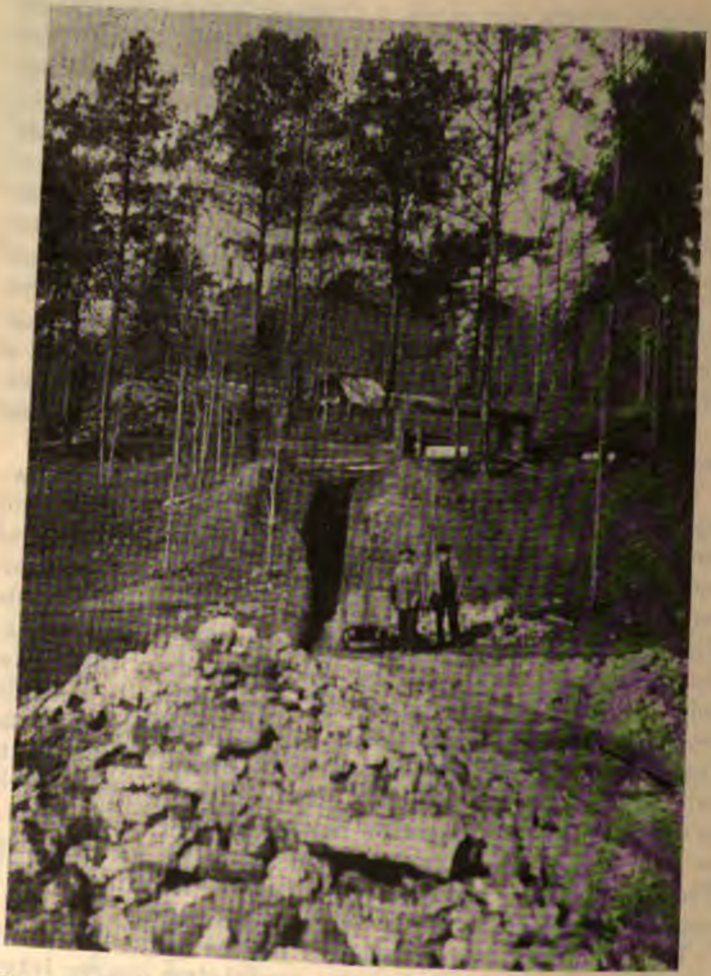

PLATE II.—ARNOTT MICA MINE—VIEW LOOKING W. SHOWING TUNNEL ENTRY.

matite body as far as developed, lies in definite conformity with the enclosing mica gneiss, and with the prevailing dip and strike of the country rocks.

Practically no mica was mined during 1920, owing mainly to unsatisfactory marketing of the product recovered during the previous year, amounting to between 40 and 50 tons. This fact appears to have been largely due to inexperienced preparation of the sheet mica stock offered for sale, and to a considerable extent disposed of on the run-of-mine basis, the grade of the mica recovered, judging by examination of some 2,600 pounds of mine run sheet now in the house, being much above average, and grading to fair and occasionally large sizes of clear, flat, amber muscovite, without specks or inclusions, to some extent more than ordinarly free from imperfections and therefore probably suitable for ordinary electrical if not for high potential uses.

About 16 tons of mica of all grades was stated by Mr. Arnott to have been recovered and sold in 1919, and the partially and imperfectly graded stock residue of about 18 tons, is now on hand in the mica house awaiting disposition.

A number of large crystals of mica, weighing 50 to 100 pounds or more each, have been recovered. These crystals, as is usually the case, were "tangle sheet" or imperfectly splitting on the edges, but produced some good sheet in the body of the block.

Some idea can be formed of recoverable mica percentages in the pegmatite, and of relative mine cost, from the stated fact that during the last period of operation, a small working force of three men for two weeks, and four men for the same additional period recovered approximately 18 tons of mine-run block of all classes.

Exhibit sample, serial Nos. 111-112 were taken from the Arnott mine and are representative.

Great Southern Mica Mine.—The Great Southern mica mine is located in the S. E. ¼ of the S. W. ¼ of Section 6, Township 18 S., Range 10 E., about 1 mile S. of Micaville.

It is one of the oldest and has been one of the most extensive mica developments in the State, and was last worked by the Great Southern Mica Company, who ceased operations as nearly as could be ascertained about the year 1907. The material facts in connection with the mine itself are involved in obscurity, as the mine labor employed was largely imported, very few local men ever having worked in it, and the owning and operating company from some cause allowing no one to enter it except their own employees. It was impossible to find any one now living near there who had seen the inside of the mine.

That it must have been an extensive deposit favorably conditioned, is indicated by the complete and efficient equipment of the mine, the length of its period of oper-

PLATE III.—ARNOTT MICA MINE—SPECIMEN MICA BLOCKS.

ation, and the large and regular amounts of mica observed to have been hauled from it by wagons 18 miles to Heflin, where the sheet mica was trimmed and graded in the company's shop.

Mine operation was carried on by meahs of a slope driven on the dip of the pegmatite body entered, equipped with hoisting engines, etc. The old compressor still in place shows that power drills were used in the workings, the equipment including pumps and all other auxiliary power plant and underground mine facilities—indicating an apparently satisfactory and economic operation.

High grade, flat sheet, amber muscovite, running in more than average large sizes up to 12x14 inches, is stated to have been the output of the mine.

The appearance, size, and character of the weathered mica observable in the numerous old waste heaps lying about the slope and in the sides of the seven or eight old surface cuts and shafts, would seem in some measure to confirm this statement.

Two, and possibly three, distinct pegmatite formations are traceable on the property of indicated N. E.-S. W. extension, but approaching a strike of due east and west, the mine proper being located on the most easterly of these deposits. All the old shafts and the slope having fallen in, no examination of the mine could be made. It is stated that the mine will be shortly reopened, and operation of it resumed, either by the Great Southern Mica Company or its successors.

Edwards Mica Mine.—The Edwards mica mine is located in the S. W. 1/4 of the S. E. 1/4 of Section 6, Township 18 S., Range 10 E., being on property immediately adjoining the Great Southern on the east.

It has been worked at various times in a small and intermittent way by different people, and is at present owned and in process of development by the Consolidated Mica Company of South Bend, Indiana.

Recent exploitation by the Consolidated has been by means of four shafts, and several open cuts, all located in the S. W. corner of the lot above described. Under the former and last preceding ownership of Mr. H. E.

McCormack of Birmingham, Ala., the old pits just E. of the Great Southern property line were reopened, and several tons of clear amber muscovite sheet of medium to large size were recovered from an extensive bed entered of a pure white kaolin of porcelain grade.

This plan of development has been abandoned by the present operating company in favor of recovery by means of five shafts, spaced at intervals of about 300 feet, along a line running due E. from the old surface cuts, following, and being driven down in a pegmatite lead having a local strike of 70°, N.W-S.E., and a dip, difficult to determine, but approaching the perpendicular.

No accurate idea can be formed of the thickness or of the extent of the micaized pegmatite body entered by these shafts, as no cross entries have been as yet driven.

The observed characteristics of the pegmatite to the depth reached, are a predominating partially kaolinized feldspar, accompanied by small chips and angular fragments of quartz, except in the most westerly of the shafts, in which a considerable body of massive white quartz was encountered and driven through. The foot and hanging walls of the pegmatite not having been reached, their character has not been determined but is probably the red mica gneiss generally observed in other occurrences near by.

The two most easterly shafts have been driven to a depth of 26 feet, partially timbered at the bottom, and contained some water. The third shaft, driven centrally of the group, to a depth of 25 feet, has a N. entry at the bottom, 15 feet in length, which was said not to have yet reached the N. wall of the pegmatite. Some 20 tons of white quartz was removed from this shaft in sinking, along the contact with which quartz several tons of mica were recovered. The shaft lies altogether in hard material and is not timbered. West of this shaft about 25 feet, another shaft 18 feet deep has been sunk, and a third shaft, some 25 feet still further W., to a depth of 25 feet; the latter shaft, solidly timbered from top to bottom and containing some water, being bottomed in the kaolin bed opened up by the adjoining surface pits previously mentioned.

Very little of the mica recovered from these operations came from the two easterly shafts, most of it having been taken as stated from the central shaft. The total output, the amount of which could not be ascertained, was said to be represented by about 12 tons of crude mine-run mica stored in Mr. Pat Ayers' barn, which was examined and is represented by exhibit sample serial No. 113.

Liberty Mica Mine.—The Liberty mica mine is located in the S. W. ¼ of the N. E. ¼ of Section 1, Township 18 S., Range 10 E., being about ½ mile S. W. of Micaville, and ¼ mile S. of the Cleburne county line.

It is understood to be owned and operated by the Liberty Mica Company. Considerable development work was done on this property during 1919-1920, but work was practically discontinued during the last half of 1920.

The original opening up of the mine prior to present ownership was by an open cut along the outcrop about 100 feet in length, in which cut the mica was crudely won by stoping down on the pegmatite some 20 or 30 feet at points most obviously micaized. Recoveries in these earlier operations were largely if not altogether of A-formed mica, of therefore inferior non-sheet grade, which is characteristic of the deposit near the surface. Observing the change to more perfect forms of crystallization in the mica blocks at lower levels, present operators later on opened the mine by means of shafts and by a subsequent and final slope operation as shown in Figure 4.

In all, five shafts have been sunk, in the relative positions shown on the general plan of the mine, to intersect the pegmatite at various levels.

The pegmatite body entered, has on the outcrop an apparent strike of about 50° N.E.-S.W. and a dip S.E. of 40°-45°.

The main working shaft D., is 35 ft. in depth, with a horizontal entry running N. at the bottom for a distance of about 40 feet. From this entry the S. stope or working heading, 60 feet in length E., and the N. heading, 35 feet in length E., were driven down on the dip of the ore body. From these workings, the larger part of the mica recovered in the mine has been taken out. Subse-

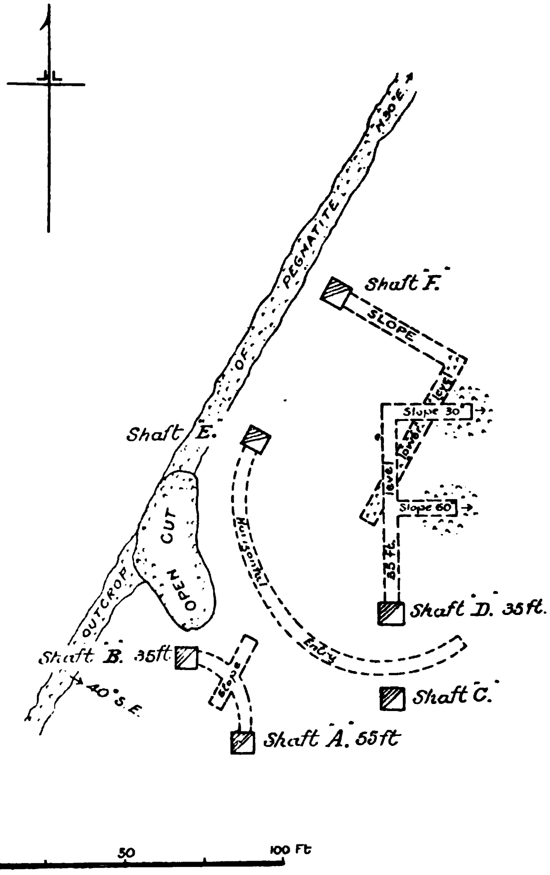

Figure 4.
PLAN of THE LIBERTY MICA MINE.
S 1. T 18 S. R 10 E.

quently, a slope was started at F. near the outcrop, and driven down under the above described workings, approximately as shown on the plan, which was the point of active development at the time of the cessation of last operations.

Shafts A., B., and E., were largely experimental prospecting. Shaft A., known as the "Zeissmann" shaft, is 55 feet deep and was originally connected with shaft B., which has a depth of 35 feet, by a circuitous entry. Very little practical information or benefit appears to have been gained from these two shafts, although some good mica was recovered from there. Shaft E., located near the outcrop, was further exploited by another circuitous entry intended to reach shaft D., with which it is understood it was finally connected. All these operations appear to have been largely preliminary to the final and practical development of the mine as above described by means of shaft D., and the slope.

The pegmatite body developed is a coarse aggregate of fairly uniform width, having a maximum thickness in the mine workings of 18 feet, and containing few if any inclusions, partings, or horses. It appears to lie in general conformity with the enclosing rocks which are red mica gneiss.

As above stated, the mica recovered in all workings near the surface, was mainly of A-form, but in the final and lowest working levels and entries, flat mica, of steadily improving grade, replaced almost altogether the surface mica of defective crystallization. It was found to be located along the contacts, and mainly with the footwall, and in kaolin.

Some estimate may be formed of the ruling mica percentages in the "vein", and the cost of recovery, from the stated fact that in final slope operation, from 2,200 to 2,600 pounds per day was the average with a working force of 5 men.

The best expectancy of this mine, both as to grade and amount is indicated as carried below water level and has not as yet therefore been determined.

As stated by the superintendent Mr. Tapley, the gross amount of mica recovered by the present operating company has been approximately 40 tons. About 32,000 pounds of run-of-mine block was weighed up, out of which 3,100 pounds of smooth flat amber muscovite was sheeted and sold. As in all these mines and prospects, practically no scrap has been made use of or as yet sold.

Exhibit sample, serial Nos. 114-115 are from the Liberty mine.

Pinetucky Mica Mine.—The old Pinetucky mine, which is historically believed to have been the first mica mine worked commercially in Alabama, is located in the N. W. ¼ of the S. W. ¼ of Section 12, Township 18 S., Range 10 E., and now belongs to the extensive holdings in this county of Mr. Sam Wallace, one of the pioneers of the Micaville district and its principal factor of present and past development.

According to Brewer*, who examined it thoroughly in 1890, going all through the then extensive underground workings, the deposits of pegmatite entered, made up of several distinct parallel leads or "veins" all having a N. E.-S.W. strike and a S. E. dip, are well marked, extensive and unusually micaized.

Mica crystals, yielding good flat clear-sheet muscovite running to 10x12 inches in size and in considerable amounts to 6x7 inches, are reported by Brewer to have been at that time taken out, sheeted and sold to the stove trade from this mine.

None of the old workings may now be entered, but their extent is evidenced by a central shaft over 60 feet deep, two tunnels, and by some 30 or 40 old cuts and prospect pits, being the developments made by the Alabama Gold Belt Mining Company during a period of operation extending from 1890 to 1893.

The discovery at that time of rich veins of gold on the property in these mica mine workings, caused it to be abandoned as a mica mine in favor of a recovery of the gold values carried, which later on resulted in extensive gold mining, and in the erection of the present reduction plant belonging to Mr. Sam Wallace, located on the adjoining lot.

No attempt has since been made to resume mica mining on the property which the indicated facts would seem to amply justify, as the old workings, in part at least, might possibly be reopened without much difficulty.

The rotted and weathered mica observable on some of the old dumps, is of a size and quality to bear out apparently Brewer's statement relative to the grade of mica constituting the reported output of the old mine, of which there can be no doubt.

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*Report of Wm. M. Brewer, Asst. Geologist, Bulletin No. 5, Ala. Geological Survey, 1897.

Schefner Mine.—The Schefner mine, originally opened by Mr. Frank Schefner, in 1919-20, is located in the N. E. ¼ of the N. W. ¼ of Section 1, Township 18 S., Range 10 E., being ½ mile west of Micaville, adjoining, and lying immediately S. of, the Cleburne-Randolph county line. It has recently been acquired and is now being further exploited and opened up by the Midland Mica Syndicate of Minneapolis, Minn.

Recent developments on this property have mainly centralized about an old open cut located on the Eastern Central area, together with an old working mine shaft at present 64 feet deep, from which flat mica of good sheeting quality, running to large sizes, is known to have been recovered by Mr. Smith of Wetumpka, Ala., including some larger crystals, one weighing 300 pounds. Examination of old weathered mica in the dumps appears to be confirmatory of these statements.

Examination of the old shaft, which had not caved in to any extent although not timbered, showed a circular chambered out stope at the bottom all around the shaft base, carried out as far into a kaolinized pegmatite deposit as was safely possible without timber sets and proper lagging for roof support. No entries had been driven either with the strike of the chute or across it, so that the walling and the form of the pegmatite body has not been defined. The pegmatite aggregate is largely made up of quartz, in and around which the mica is carried, but appears to have been robbed out before abandonment of the operation, such mica as remained being principally small, but of flat sheet.

Several new shafts and a number of new and old prospect pits, have been opened up near the old mine shaft above described, located on outcrops, mainly in and around the edges of a well-defined and extensive outcrop of quartz.

As defined by these developments, the pegmatite leads here opened up, of which there appears to be several, have a general N. E.-S. W. strike, dipping S. E. at various, but generally steep angles.

With one exception, none of these prospect pits has been carried deep enough to develop anything but surface mica, which was recovered to greater or less extent in nearly all of them, some of it of A-form, other and deeper pits carrying flat mica of better grade.

In the one shaft carried to a depth of 32 feet, mica shows on all four sides and all the way down, some of the crystals being of large size. On the W. side of this shaft, a quartz horse was driven through for a distance of 20 feet.

Near the S. W. corner of the property, just E. of the W. property line, and within a few yards of the "Old Indian Pits," located on the adjoining property, an old surface cut had been cribbed and converted on the E. end into a shaft, which was then lowered some 15 ft. and subsequently abandoned as unsafe without proper timber sets. The mica recovered from this shaft was largely small but of fair quality. Exhibit sample serial No. 116 is from the Schefner Mine.

Indian Mica Mine.—Location, the N. W. ¼ of the N. W. ¼ of Section 1, Township 18 S., Range 10 E.

The property has recently been purchased by the Alabama Mica and Manufacturing Company of Baltimore, Md., and its immediate development by this owning company is announced, together with other properties in the immediate vicinity also formerly owned or recently acquired.

There has been no recent prospecting done. The old mine workings, some of which are by tradition ascribed to the Cherokee Indians, consist of two circular 50 foot shafts connected by tunnels with a large and deep cut bearing evidence of extreme age.

Judging by old books dug out of the dumps, the mica recovered in the cut and in the shafts and tunnels, was not of A-form but flat sheet of good quality and fair sizes, which is said by old residents to have been its character. The output, seemingly, should have been considerable and the grade satisfactory to justify the extensive developments made under the crude methods employed.

Crystal Clear Mine.—The location of this mine is in the S. E. ¼ of the N. W. ¼ of Section 1, Township 18 S., Range 10 E., lying immediately W. of the Liberty mine. It is owned and operated by the Consolidated Mica Co., of South Bend, Indiana.

The pegmatite dyke entered has a definite indicated strike across the property of about 45° N.E.-S.W., dipping 40-50° S.E. As far as developed, it lies in quite regular conformity with the enclosing red mica gneiss, and carries a fairly uniform width of about 10 to 12 feet.

The pegmatite is made up of an aggregate of small fragmentary quartz and feldspar, the latter being largely kaolinized. The mica recovered had been, prior to the examination, altogether in small sizes but of flat clear sheet of good quality.

The first shaft sunk, set off too far E., did not reach the dyke at a depth of 20 feet, and was abandoned. It is uniformly gneiss walled from top to bottom. Subsequently, two more shafts were sunk nearer to the outcrop, one 15, and the other 30 feet in depth, connected on the 15 foot level by a crooked horizontal entry following and lying in the pegmatite, the mica mined, recovered from these workings, being hauled to the surface from the main shaft by windlass and bucket.

The operation thus far has been crude and in the nature of a prospect, and has not been properly placed or of sufficient extent or depth as yet to constitute any proper proof of the mica reserves present or of their character. Near the S. W. corner of the property, and possibly on the S. W. extension of the dyke opened at the mine, an outcrop of pegmatite shows up very plainly, which near the surface is heavily micaized. It has been driven into on the adjoining property a few feet only S. of the property line, and large blocks of A-form mica exposed in the contact next the hanging wall, bedded in and on massive quartz. Exploitation of the pegmatite at this point on the property owned, would be promising, and could be easily and effectively done.

Week's Mine.—Location, the N. E. ¼ of the N. W. ¼ of Section 7, Township 18 S., Range 11 E., near and S. E. from and cornering with the Great Southern mine. The mine is owned and is being opened up by the American Mica Mining Co., of Minneapolis, Minn.

Development work so far has been directed toward ascertaining the form, character, and precise location of the pegmatite dykes, of which there are several carried in the hill where the mine proper will be opened up.

Topographically, this hill or section of a ridge is of N. to S. extension, rising some 70 to 90 feet above neighboring branch or creek level.

It is crossed near its northerly end by two and probably three pegmatite dykes, striking about N.70°W., and dipping S., at angles not yet fully determined.

Country rock measures on the contrary, near and on the surface, appear to carry the average ruling N.E.-S.W. strike of the district, indicating a cross formation; which condition appears to be closely paralleled also on the Edwards property immediately N. of it, and previously described, as also may be the case if the facts were ascertainable in the Great Southern mine.

Considerable old mining has been done on the property both for mica and for kaolin, presumably by or for the Alabama Kaolin Company about the year 1888, evidenced by an old shaft originally 40 ft. deep but milled in about 10 feet, also by a surface cut some eight to 10 feet deep, said to have been opened up principally for kaolin, samples of which clay were among those tested favorably for porcelain manufacture by Trenton potteries. Some of the largest and best mica ever recovered in the Micaville district are stated by Mr. Pat Ayres to have been taken out of this old shaft, which is now being timbered up preparatory to re-entry of the old underground mine workings. Preparatory to this development, the old cut next to the outcrop was cleaned out and lengthened along its N. E. strike, an included quartz horse being taken out with recovery of some 1,600 pounds of flat mica in small sizes next the upper contact and around the quartz horse. The old working shaft now being re-opened lying at the proper distance south of this outcrop tested, is correctly placed to reach this pegmatite body and develop it at proper levels. Water level is indicated at approximately 70 feet.

On the central pegmatite dyke, at a point about 200 feet N. of the old working mine shaft, a surface outcrop was first opened up by a shaft, from which a favorable recovery of large crystals of weathered and clay stained surface mica was made.

From the bottom of this shaft, at a depth of 10 feet, a slope has been driven down following the dip of the pegmatite immediately under the hanging wall, at a slope angle of 30-35°, due S. in direction, for a length of 62 feet. At the slope head, a quartz horse was blocked out, and left standing for roof support.

The pegmatite body followed is very irregularly lenticular, with frequent intrusions of the peculiar red mica gneiss walling, represented by exhibit sample, serial No. 117. The foot wall is apparently at no point reached along the floor of the slope, kaolin showing in this floor. The thickness of the dyke is therefore not determined, but as far as proven is in excess of eight feet. The apparent narrowing or pinching out at the bottom of the slope may be intrusive, or a roll in the foot wall.

The special characteristics of the pegmatite, are a coarse aggregate, the feldspar largely kaolinized, and a dissemination of kaolin in small streaks through the mica gneiss intrusions as shown by exhibit sample, serial No. 118.

About 5 tons of mica, a large proportion of which was flat sheet of fair sizes, some of it of very high grade, was recovered in sinking this shaft and slope, most of it being taken from the hanging wall contact, where a number of fine crystals were still in place at the time of the examination.

Exhibit sample, serial No. 119, was taken from the roof contact midway of the slope, and represents the grade of mica recovery. It is an amber muscovite, in flat sheet, carrying few imperfections and is free splitting, of very satisfactory grade, indicating an expectancy of high grade mica from this mine when carried down to the lower levels, and fully developed.

Occurrences of kaolin are in small streaks and beds intermixed with granular quartz distributed uniformly through the pegmatites.

The micaized continuity of the dyke N.W.-S.E. has not as yet been determined either on the surface or by entry cuts from the slope.

The exploitation of this property, which contemplates also boring tests, is being carried on in a thorough and competent manner by experienced mining men, and by first establishing all the main essential facts relative to the form, character and precise location of the deposits to be entered for a permanent and economic mine recovery has already very encouraging and satisfactory prospects.

Consolidated Mica Mines.—During 1918, a selected group of mica properties aggregating about 600 acres was acquired by the Consolidated Mica Company of South Bend, Indiana. Extended prospecting has since been done on these properties, several producing mines having been opened up, the output of which was shipped to the manufacturing plant operated by the Consolidated Company at South Bend.

Mention has been previously made of two of these properties from which this output of mica was mainly drawn, viz; the Edwards, and the Crystal Clear mines.

No mica having been sold by this company, the total amount recovered being as stated required for its individual plant consumption, the precise amounts of mica taken out from this group of properties were not ascertainable and can not be stated or approximated.

The general and preliminary exploitation which was desired and undertaken of so large a combined property, necessarily limited the amounts of actual mining done, (which awaited the determination of the most favorable points for mine entry) and tended to restrict the prospecting largely to shallow tests, affording no reliable idea of possible expectancy as to the amount, and more especially in the matter of the grades of mica recoverable at proper levels.

Active mining was discontinued during the early part of 1920, and has not yet been resumed by this company.

Acknowledgment is due the superintendent of the Consolidated Co., Mr. J. M. Seabrooke for information furnished and for assistance given in going over the work done under his direction at the following localities:

The S. W. ¼ of N. W. ¼, of Section 8, Township 18 S., Range 11 E.—One, and probably two, distinct and parallel leads of pegmatite are indicated by outcrops as crossing this lot with an observed strike of N. 45° E., dipping S. E. Developments made were on the most westerly of the two leads, near the center of the 40, and consisted of shafts about 20 feet in depth, one of which being wrongly located developed nothing, the other yielded only small mica from a kaolinized dyke made up of an aggregate of small angular fragments of quartz in formative kaolin.

S. W. of this shaft, in a bluff on the creek bank, the same pegmatite body is exposed under a massive overlay of quartz, carrying some sizable mica crystals next to the upper contact. The developments made on this lot have not been properly located to have any material bearing on the possible mica values carried.

The N. W. ¼ of N. E. ¼ of Section 6, Township 18 S., Range 10 E.—Two leads of pegmatite of N.E.-S.W. extension are traceable across this property. On the most westerly of these leads, a shaft was being sunk at the time of the examination in which shaft good flat mica of fair size and in considerable amounts was being taken out near the bottom, mainly recovered from the upper or hanging wall contact of a kaolinized pegmatite dyke eight feet in thickness, the foot wall having been not yet reached.

On the easterly lead, pegmatite shows up just south of the house in an outcrop of quartz, but no testing had been done here or elsewhere on this lead.

The S. E. ¼ of N. W. ¼ of Section 6, Township 18 S., Range 10 E.—Two and possibly three pegmatite formations are traceable across this property of N.E.-S.W. strike. Developments have been limited to the sinking of two pits in the S. W. corner of the lot, from which, to the depth reached of about 15 to 20 feet, only A-form mica in small amounts had been taken out.

S. W. ¼ of N. W. ¼ of Section 6, Township 18 S., Range 10 E.—Known as the

"Bagley Tract."—Exploitation in a limited way as yet has been by means of five pits, located, two in the S. E., one in the S. W., and two in the N. W. corners of the 40. In the N. W. corner, E. of the road, a shallow 8-foot pit developed a recovered small amount of A-form mica. A second pit, opened up 200 feet W. of the first one, showed about the same conditions, as did also the pits sunk in the S. E., and in the S. W. corners of the lot close to the W. property line. Just across this line, on what is known as the

"Alexandria Lot," there is a closely combined group of some five or six old open cuts in which a fairly good showing of A-form and of some good flat mica was observable. As the pegmatite opened up by these old workings has an indicated N. E. extension apparently into and across the "Bagley Lot," it may, by competent prospecting, be traced up and found to be there similarly micaized. The openings on the N. W. corner of the lot are said to have been made under the direction of Prof. Bain of the University of Minnesota, and appear to have been suggested by an observed and heavy outcrop of quartz, but lie altogether in soft mica schist and were not of sufficient extent or carried to sufficient depth to afford much information of importance as to pegmatite conditions existing under or associated with the quartz.

The N. W. ¼ of N. W. ¼ of Section 6, Township 18 S., Range 10 E.—Known as the

"McAdoo Lot."—No recent work has been done on this 40, which was at one time developed, and mica recovered, from an old shaft and tunnel located in the S. E. corner of the property. These old workings are now inaccessible, and nothing definite is ascertainable about their history or as to the mica recovered from them.

The S. E. ¼ of N. E. ¼ of Section 2, Township 18 S., Range 10 E.—Property immediately adjoins the "Arnott" Mine. On the east, near its N. E. corner, a pit 8 feet deep, opened up on a pegmatite outcrop striking N.40°E., and dipping 30° S. E., developed some good flat mica of small to medium sizes carried in a dyke about 3 feet in width. Near the N. W. corner of the lot, two pits have been sunk to a depth of 20 feet, developing nothing because improperly located. Proximity to old workings from which good mica is understood to have been taken out, especially in the old tunnel which has since caved in, led to these attempted new developments.

The E. ½ of S. W. ¼ of Section 4, Township 18 S., Range 10 E.—Practically in the centre of these two 40's, an open cut about 10 feet deep exposed a pegmatite dyke dipping S. E. under a quartz hanging wall, carrying interbedded on and below it masses of A-form mica of large size. Five feet of pegmatite below the quartz has been cross cut, with the foot wall not yet reached. The form of crystallization improves at the bottom of the stope driven under the quartz, the A-form showing a marked tendency toward alteration into sheet mica, some good books being found in the upper contact.

One-half mile due west of this pit, and about the center of the W. ½ of the S. W. ¼ of the same section, a similar but larger old entry cut about 100 feet in length develops closely parallel conditions, the pegmatite entered carrying heavy quartz exposures on the hanging wall, below which masses of A-form mica of very large sizes are imbedded. Several smaller pits adjoining the cut also contain mica exposures, but so covered up by the milling in of the old slopes as to afford very little information of value as to the deposit.

All of the above described developments are as stated located on the properties of the Consolidated Mica Company near Micaville.

Competent expert tests were made by this company of mica stock shipped from their mines to the South Bend factory, to determine its commercial value as electric mica. Through the courtesy of Mr. J. R. Garn, Treasurer, the following records of official dielectric tests made on average samples of Micaville stock, drawn in the rough, and not as customarily prepared for testing, will still serve to show a very acceptable commercial grade of electric mica.

Report on electrostatic test of mica samples, submitted by the Consolidated Mica Company. The samples were split to suitable thickness and tested between ball terminals at 60 cycles, alternating current, the voltage being applied gradually until the breakdown occurred.

Sample. No.	*Thickness of Sample in Inches.*	*Average Voltage Per Mill. Thickness of Sample.*
1	.0135	1530
2	.0025	4600
3	.00325	4200

The results of the test on samples Nos. 2 and 3 indicate a high dielectric strength.

The comparative low voltage per mill of sample No. 1, was due to the condition of the sample, in that cracks were present.

CHAS. A. NASH,
Consulting and Testing Engineer,
3300 Federal Street, Chicago, Ill.

August 12, 1920.

Report on electrostatic test of 12 samples of mica, submitted by the Consolidated Mica Company, from their mines at Micaville, Alabama.

PUNCTURE TEST ON MICA SAMPLES.

Ref. No.	*Sample*	*Size*	*Thickness*	*Break-down Actual*	*Voltage Per Mil.*	*Surface Leakage*
1.	A.	3½"x5½"	.004	9600	2400	
2.	A.	3½"x5"½	.0035	8400	2400	
3.	A.	3½"x5½"	.005			3"—13440
4.	B.	3" x5"	.0065			2½"—14640
5.	B.	3" x5"	.0045			2½"—12480
6.	B.	3" x5"	.0035			2½"—12240
7.	B.	3" x5"	.0025			2½"—12000
8.	B.	3" x5"	.002	7920	3960	
9.	C.	3" x4½"	.002			2½"—10500
10.	C.	3" x4½"	.001	6720	6720	
11.	C.	3" x4½"	.001	7440	7440	
12.	D.	4½"x8"	.005	14400	2880	

Samples with the exception of "D" were split because of small size.

Bottom electrode flat and 1" in diameter.

Top electrode ⅜" sphere.

INDIANA AND MICHIGAN ELECTRIC COMPANY,
South Bend, Indiana.

August 19, 1920.

Stockdale Mica Mine.—The Stockdale mica mine, originally known as the Bell and Kilgore mine, is located partly in the S. E. 1/4 of the N. E. 1/4 of Section 25, Township 18 S., Range 10 E., and partly in the N. 1/2 of the S. W. 1/4 of N. W. 1/4 of Section 30, Township 18 S., Range 11 E., immediately adjoining it on the east, and is about 5 miles S. E. of Micaville.

The property is not reported to have been recently mined, but when last examined, in December, 1917, had just been acquired and was being reopened with a view to operation by R. W. Stockdale, T. A. Cornwall and L. F. Haggard, of Gadsden, Alabama. At that time the main developments were the old Bell and Kilgore workings in Section 30, opened up in 1915, which consisted of a shaft and slope, both driven to water level, and there as usual, abandoned for lack of pumping facilities.

Both shaft and slope contained water and could only be examined to that level.

The pegmatite developed by the shaft and slope has a strike of 40°, N.E.-S.W., and a dip S. E., of 60°. To the depth visible, it is apparently altogether kaolinized, containing crystalline quartz, mainly in small angular fragments, the mica being distributed through the mass.

When previously examined in March 1916, there was in the mica house approximately 5,400 pounds of mica, said to have been taken out of the shaft and slope, of which amount 1,400 pounds had been thumb-trimmed, about 2,500 pounds run-of-mine, and the remaining 1,500 pounds, scrap.

The mica stock recovered was a light amber muscovite, running to fair sizes in flat sheet, some of it of high grade, being the remnant of a worked over stock, the total amount of which recovery could not be reliably ascertained.

Developments in Section 25, consisted of six or more shallow surface cross-cuts, opened up in testing four distinct leads of pegmatite, indicated by outcrops as crossing the Section parallel to the pegmatite deposit opened up in Section 30, having the same strike and S. E. dip.

The mica still remaining in these cross-cuts was all small, but of flat sheet of exceptionally high grade.

In the most westerly of the cuts, on the east bank of a small branch or creek running south through the property, the pegmatite exposed carried a bone quartz containing red oxide of iron, with occasional particles of free gold, resulting from oxidation of sulphurets, the branch gravel below the vein affording very fair gold values in the pan.

Douglas Smith Mine.—The Douglas Smith mica mine is located in the S. E. ¼ of the S. E. ¼ of Section 22, and in the N. W. ¼ of the N. E. ¼ of Section 27, Township 19 S., Range 10 E., being about ½ mile E. of Coosa river and 3 miles N. of its junction with the Little Tallapoosa. It is the property of the Randolph Mica Company, of Wedowee, Alabama.

The mine location is about midway of the slope of the ridge bordering Coosa river along its east bank, at an approximate elevation of 700 feet above sea level, and is in the S. E. ¼ of the S. E. ¼ of Section 22. Some developments have also been made in the N. E. ¼ of S. 27, but the mine proper as so far developed, is in Section 22.

A body of pegmatite presenting a bold and clearly marked outcrop, has been driven into by means of an open cut in the side of the hill. The character of the pegmatite is a coarse aggregate containing quartz in considerable amounts and of large size, in and around which the mica has been mainly carried.

Mining conditions are therefore unusually favorable, and at the time of the commencement of the late war it was in active operation under the direction of Col. Dallas Smith of Wetumpka, the experienced superintendent being Mr. W. J. Bean. Col. Smith being called to the colors, operations were temporarily suspended and have never since been resumed.

During the last period of operation the mine was equipped with power drills, and all necessary facilities for economic operation, including a small shop provided with a complete outfit of punches, dies, trimmers, etc., in which the output was worked up, graded and sold.

The character of the mica won was exceptionally good, being a clear flat sheet muscovite in fair sizes, containing comparatively few imperfections in the form of folds, or cracks and no spots or inclusions. It was of light rum color, classing as white in the commercial sheet.

Elsewhere on the property, there is observable a deposit of crystalline flake graphite, which is however as yet undeveloped.

Exhibit sample serial No. 120 is from this mine, at the main opening in Section 22.

CLEBURNE COUNTY.

Cleburne County is comprised within three distinct physiographic belts: the Appalachian Mountain, Piedmont Plateau, and the alluvial area made up of the Tallapoosa river bottoms.

The mica belt or zone, which occupies the approximate central part, runs N. E. to S. W. through the county, lying altogether in the Appalachian.

Topographically, it is principally a deeply eroded plateau, containing many sharp and narrow, and some broad ridges, having summit elevations of 1,000 to 1,500 feet above sea level, its western boundary line being the Tallapoosa river.

In the southern part of the county, within the mica bearing district, areas of the Appalachian Mountain belt are outlying, comprising notably Turkey Heaven, Kemp, and Bald Mountains, and the vicinity of Chulafinnee.

The underlying rocks are mainly mica and hydro-mica, talcose, garnetiferous and hornblende schists, gneiss, and quartzite conglomerates. The quartz occurs mainly in veins, which are in many places gold bearing.

Mica occurrences are in the pegmatites which are of irregular formation in the gneiss and mica schists, with frequent hornblende association, together with surface float of highly crystalline, translucent, and transparent quartz, in fragmentary form, cyanite, and ferro-magnesium rocks.

The Chulafinnee, and the Arbacooche localities, which were active and notable gold mining camps prior to the discovery of gold in California lie within the mica zone of Cleburne, as does also the Turkey Heaven Mountain area which similarly carries numerous gold veins more or less productive at various periods of free gold, little or no experienced handling practically having ever been given to the sulphurets.

Although some of the largest and best mica ever recovered in Alabama came from Cleburne county, comparatively little prospecting for it has been done, apparently owing to attention having been largely centered on the occurrences of gold and other minerals considered more profitable.

There is much evidence of mica occurrences wholly undeveloped to justify such competent and experienced mica prospecting.

It is a curious fact in this connection that in the grave of a Cherokee Indian which the writer saw opened up, the skeleton was found completely enclosed in a stone box made altogether of large blocks of mica, forming the floor, top and sides. These blocks, or sections of split crystals, were most of them amber muscovite mica of good grade, extremely light in color, and necessarily of very unusually large size for the purposes stated. The precise origin or source of this mica is of course purely conjectural, but as its color, crystallization and all of its characteristics are in precise conformity with mica since recovered in that particular section of the Cleburne mica field where the grave was located, it is a fair presumption that its origin was in all probability not far distant.

While there are a great many outcrops and small old dog-hole prospects scattered through the belt, attention has been called to recent attempts at development only on the Morris and on the Jim Flemming properties.

Morris Mica Mine.—The Morris mica mine is located near the center of the N. E. ¼ of the N. W. ¼ of Section 21, Township 17 S., Range 10 E.

The pegmatite body exposed by outcrops, lies on the summit, and follows closely the upper edge of the northern escarpment of a steep high ridge, of N.E.-S.W. extension, having a summit elevation of 1,000 feet tidal datum, and a rise of over 200 feet above the Tallapoosa River, the run of which is along the foot of the ridge, N. of the mine, and about ¼ mile distant therefrom.

The northern escarpment of the ridge below the mine is abrupt, falling off at a uniformly steep angle of pitch down to the Tallapoosa valley level.

The deposit of pegmatite opened up is, as to district location, placed near the westerly edge of the zone of mica schists generally constituting the mica belt of Alabama, and differs from the formations prevailing in that easterly section of the belt, in respect to being in part made up of basic and igneous rocks, containing hornblende and other ferro-magnesium schists. Local surface occurrences noted, characteristic of this section of the belt, consist of hornblende schists, highly crystalline and translucent quartz, garnetiferous schists, cyanite, etc.

The pegmatite dyke entered lies in apparent conformity with the enclosing formations of garnetiferous red mica schist; has a definite strike of N.40°E., dipping S. E., back under the ridge, at an angle (on the surface) of 30 to 40°.

The pegmatite outcrop is traceable on the surface, and is continuously more or less micaized, for a distance of about 200 feet along the strike each way, (N. E. and S. W.), from the therefore central point of first development, beyond which terminal points, the ridge falling off, it is covered by shallow residual soil, but may be easily uncovered and its continuity and micarization possibly somewhat extended and examined.

Developments thus far made, consist of surface pits lying in and along the outcrop, but without proper cross cuts to determine the width of the ore body, which however, has been shown to have an observed minimum thickness of 10 feet, with neither foot nor hanging wall as yet revealed.

Characteristic features of the pegmatite are a coarse aggregate of crystalline and semi-crystalline quartz, with feldspar, which has been but very little decomposed or kaolinized.

The mica carried, and recovered from the pits, is in more than usually large crystals very generally sound and tight and free from clay stains or inclusions, and was found distributed through the mass; the upper and lower contacts, where the micaization is usually centralized, having not yet been opened up or reached.

The freedom of the deposit from crustal movements, is clearly shown by the regularity of all the revealed measures, and is further evidenced by the quite unusual absence of folding or pressure cracks in the mica crystals, which in large measure show perfect forms of crystallization. A limited amount of A-mica was taken out in one pit only on and near the surface, but this defective form of crystallization appears to be entirely confined to this one small locality in the chute as opened up, lessening, and being practically replaced by flat-sheet crystals at the bottom of the cut, a percentage of good flat sheet being in fact recoverable from most of the A-form crystals taken out.

The mica recovered is an amber muscovite of unusually high grade for such surface crystals, splitting well, generally clear sheet, and running in sizes already to 3 x 4 inches.

Mining conditions for economic recovery are most favorable, as the deposit is so readily understandable as to be capable of a complete proving out of all necessary data relative to the proper and most competent and economic points and method of entry before opening up the mine, and has an expectancy of dry mine workings to a considerable depth, as well as of a recovery of sound crystals of flat sheet almost from the surface.

The property belongs to and is being developed by, the Midland Mica Syndicate, of Minneapolis. Exhibit samples serial No. 121 are from this deposit.

Jim Flemming Mine.—The precise location of the Jim Flemming mine could not be ascertained, but its approximate location is in Section 24, Township 17 S., Range 10 E.

It is the property of Mr. Harry Vaughn, and was opened up by Mr. Maddox about the year 1916. The deposit exploited lies high, on the summit of a flat or slightly rolling ridge, at approximately an elevation of 1,000 tidal datum.

It is marked on the outcrop by heavy masses of quartz containing large hornblende crystals (which are scattered thickly over the ground in cultivated areas below the outcrop), has a strike of N.50°E., dipping about 40° S. E., and has been partially opened up along the strike by test pits for a distance of several hundred feet.

First developments stated to have been made by Mr. Maddox was by means of a surface cut, 10 feet deep, of E. and W. extension, intended as a cross-cut. In this cut or pit, a very coarse pegmatite was exposed, made up of a generally unaltered feldspar in large aggregate, interbedded with masses of quartz containing numerous and large hornblende crystals, the mica observed being in fairly large crystals chiefly placed along the quartz contacts, but to some extent carried in the feldspar, where partially kaolinized.

As examined in the cut the mica is a flat muscovite of light amber color, in fair sizes, but tangle-sheet edged, or not free splitting, the sheets being interfoliated with a white incrustation.

Subsequent development for systematic mining was carried on by means of a slope, driven down in the pegmatite body proper from its outcrop, at a point about 75 yards S. W. of the first described pit, and following the dip S. E.

The full width or thickness of the pegmatite, indicated as 6 to 8 feet, was taken out in this slope entry, revealing a top and bottom walling of red mica gneiss.

At the 90 foot level, or the foot of the slope, a left entry had been run out N. E. about 20 feet. The mica recovered from the slope and entry; estimated to be in all about 6 to 8 tons, is at present stored in the mica house precisely as taken out, and is run-of-mine, none of it having been worked up or sheeted. It runs quite uniformly as to size in 2x3 to 4x4 or larger blocks.

From the number of crystals left in place along the hanging wall contact, that contact seems to have been as usual the heaviest mica concentration in the deposit.

Exhibit sample serial No. 122 is drawn from the stock house run-of-mine, on this property.

CLAY COUNTY.

The mica bearing section of Clay county, which lies within the drainage area of the Coosa and the Tallapoosa rivers, physiographically belongs to the Piedmont Plateau province.

It is made up of a belt or zone of comparatively narrow ridges, which belt is from six to fourteen miles in width, entering the county from Randolph, near its northeasterly corner, and extending S. W. for a distance of about 25 miles, to the vicinity of Millerville.

The underlying rocks are mainly schists, gneisses, granites, diorites, phyllites and slates, with infrequent shales and quartzites.

A dominant structural characteristic of the rocks is their steep angle of dip and frequent faulting. The surface rocks of the micaized zone are highly metamorphosed crystallines and semi-crystallines, with frequent occurrences and intrusions of diorite and granite dykes, and mainly include feldspathic hydromica schists, muscovite and biotite micas in pegmatites, an argillaceous mica schist, sericitic, garnetiferous, hornblendic, graphitic, epidote, and quartz schists; various iron formations, and the Talladega phyllites. Carboniferous fossils found on the western edge of the mica zone or belt near Erin*, in the Talladega phyllites, indicate that part of these formations belong to the carboniferous.

The Hillabee green schist, occurring in the belt north of Delta, is a fine grained rock of olive-green color; in that locality, as elsewhere in the county, carrying numerous quartz veins.

A prevailing characteristic is the breaking down and weathering of the feldspar component of the rocks into kaolin, which has been largely the case but in lesser degree with the granites as well as with the pegmatites. Along its western edge, and extending through the county S. W., the mica belt or zone is bordered by basic and igneous formations; diorites, hornblende, and other ferro-magnesium schists, the diorites being largely metamorphosed. As in Cleburne county, the muscovite mica occurring near the western edge of the mica belt, in more or less close proximity to the ferro-magnesium formations, differs materially from the mica of the central and eastern positions of the zone in respect to color, hardness, flexibility, etc., as the specimens drawn will serve to illustrate.

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*By Dr. Eugene A. Smith, State Geologist of Alabama.

A line drawn from the Delta mica mine (which is located in the N. E. corner of the county), and having a bearing S.45°W., will be found to lie at all points about centrally of the observed and developed mica occurrences in Clay county as far south as the vicinity of Idaho, or immediately north of the Quenelda graphite mines; south of which point no mica deposits of any apparent importance or value have been as yet noted in the county, although such may be found to exist.

"M. & G." Mica Mine.—The "M. & G." mica mine is located in the S. W. ¼ of the N. E. ¼ of Section 15, Township 19 S., Range 8 E.

It lies on the summit of a ridge of N. E.-S.W. extension at an elevation of 1,100 feet, tidal datum. The deposit of pegmatite entered has a strike of N.40°E. and is traceable on the surface by visible outcrops at intervals for a distance of nearly a mile.

Original development by the M. & G. Mica Co., of Chicago, Ill., consisted of surface cross cuts and pits, extending over a mile along the strike, directed at the determination of the most favorable point of entry, which was finally selected, and the mine opened up near the N. E. corner of the above described lot.

At this point two slopes were driven 100 ft. apart in the pegmatite body, following its S. E. dip at a slope angle of about 45°. Two cross entries were driven, connecting the two slopes, the first at 75, and the lower connecting entry at 150 feet below the surface, or at the foot of the slopes; one of which was driven lower for a drainage sump.

The last examination made of this mine was in 1914, a few days only prior to its shutting down by reason of litigation arising among the property owners, since which time, and in consequence of which litigation, it has never been actively reopened.

At the time of the examination mining was in progress over both slopes with a full plant equipment of hoisting engines, air compressor and drills, etc. By the entry method adopted, two included sections of the pegmatite body, in size 100x75 feet each, had been solidly blocked out to be partially left for roof support, and in part stoped out, which however was never subsequently done.

Examination of all these exposed faces of the blocked out sections showed mica crystals to a greater or less extent on all of them, mainly carried next the upper contact and bedded on and in the included quartz masses.

Mica recoveries were altogether being made on the lower breast of the second cross entry, where there was a remarkable concentration of amber muscovite, in flat, generally perfect crystals of large average sizes, running from 2x3, to 8x12 inches.

During two successive days spent in the mine watching the recovery, 21 boxes, of 100 pounds each were taken out, nearly all of which was flat, clear sheet, amber muscovite, carrying few imperfections of any kind.

A considerable number of fine crystals still remained in the working heading after this recovery, and all indications seemed favorable to the continuation of the micaization of the chute to lower levels, which was never subsequently done, mine operations being immediately thereafter suspended for the above stated reasons.

The main characteristics of the pegmatite body entered by this mine are a very coarse aggregate of fairly uniform thickness, in excess of 8 feet; the foot wall not having been apparently reached on the slopes. A general conformity to the enclosing mica gneiss walling is indicated as far as developed. Inclusions of quartz masses or horses, micaized with imbedded crystals, are frequent; the feldspar, being but very little kaolinized. Fine crystals of mica were recovered almost from the surface down, there being no evidence of crustal movement in the form of folding, pressure lining, cracks, or imperfections, defective crystallization being largely absent.

In all, and up to the time the mine was examined in 1914, the total amount of mica recovered was stated to have been something over 160,000 pounds.

Of this amount there still remained in the mica shop, an accumulated residue stock of about 21 tons, in which the sheet mica had been all knife trimmed and graded, and was subsequently sold. It was carefully gone over and consisted very largely of mica of exceptionally high grade, running in more than ordinarily large sizes up to 8x12 inches.

No attempts were ever made to test the continuity of the micaized body N. E. or S. W. along the strike, outside the slope limits of the mine proper, or as stated at lower levels, which is to be regretted, as what may prove to be a valuable and extensive body of fine mica is here reasonably indicated.

The best grade, and the largest sizes, of crystals recovered, was, as is in this field usually the case, below water level.

Exhibit samples serial No. 123 is from this mine.

Eureka Mica Mine.—The Eureka mica mine is located in the N. E. ¼ of the N. E. ¼ of Section 16, Township 19 S., Range 8 E., being about ½ mile distant W. of the M. & G. mine and 1¾ miles N. E. of Pyriton station, on the A. B. & A. R. R. It is the property of the Eureka Mica Co., of Birmingham, Ala.

A heavy outcrop of micaized quartz led to the original development by open cut.

As subsequently mined by the Eureka Company, two slopes were driven in the pegmatite, about 50 feet apart, following it on its S. E. dip of about 40°, connected by two lateral cross entries. A main working shaft 130 feet in depth, reaching the pegmatite "vein," connected with the bottom of the east slope for an air course, as shown on Figure 5.

In the east slope, a right entry, 60 feet in length, was run out on the 60 foot level, and a second or lower right entry, about 75 feet continued on to the shaft.

The first or upper left entry at the 70 feet level, 40 feet in length; and the second or lower left, 70 feet long, connected up the two slopes, blocking out some 600 feet of exposed faces, a large proportion of which showed more or less mica crystals in the walls at the time of the examination.

Near the main slope in the upper left, and in the lower right entries, very large crystals of mica were taken out, one weighing over 200 pounds. With the exception of a few stulls, no roof support in the form of timber sets or lagging had been placed in the entries, and but little attempt at effective timbering made on the slopes in consequence of which neglect, most of this work partially caved in at the first rise of mine water, becoming unsafe and was subsequently abandoned. A heavy showing of mica observed in concentration on the upper contact at the foot of the main slope, was thereby involved in this fall, and never recovered.

The pegmatite body entered is made up of an unusual amount of quartz in large masses, around which considerable mica was recovered, the feldspar being kaolinized in the upper levels, but large unaltered in the lower entries. The unaltered spar, carried by analysis, 10 per cent. potash. The larger proportion of mica recovered, was next the contacts and principally with the hanging wall, which is a garnetiferous mica gneiss.

In all, some 50 tons of mica of all classes was recovered in this mine, very little of it being of A-form, and that only near the surface. The large crystals taken out were mainly defective on the edges, but carried good flat mica sheeting well in the body of the crystals, some of it of large sizes.

It is a flat amber muscovite of very light color, containing no spots or inclusions, and by tests made, of high dielectric quality.

The general mine run of sizes are somewhat indicated by the last graded stock sold, which ranged from circle to 6x8 inch, 10 per cent. of the lot running from 3x3, to 6x8 inch.

Owing to inability to secure competent and experienced management and to properly grade and market the mica stock recovered, the mine has been recently idle.

Exhibit samples, serial No. 124 are from this mine.

Delta Mica Mine.—The Delta mica mine is located in the S. E. 1/4 of Section 4, Township 18 S., Range 9 E., being in the N. E. corner of the county, 1/2 mile S. of the Cleburne county line. It is the property of, and has been

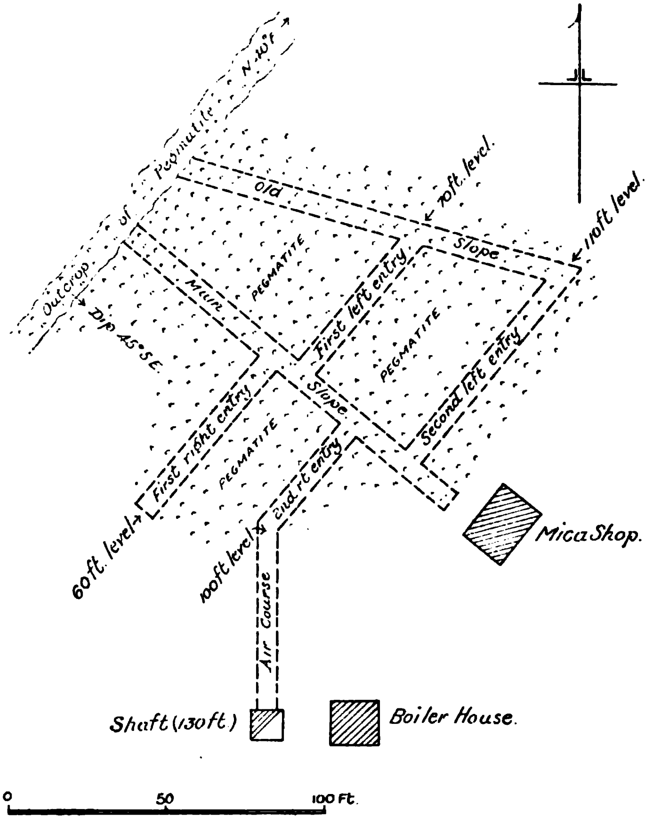

Figure 5.

PLAN of EUREKA MINE.

S16.T19S.R8E.

opened up and operated by Mr. T. C. Russell of Alexander City, Ala.

Topographically, the property lies high, being located near the summit of a rolling plateau area having an elevation of 1,100 feet, tidal datum, this plateau forming part of the western water shed of the Tallapoosa river. On Ketchepedrakee creek, which crosses the property from N. W. to S. E., a small water power has been developed in close proximity to the mine, now utilized by the Armstrong mill, which it is proposed to make auxiliary to it for power purposes.

The deposit of pegmatite entered belongs to the western section of the mica belt, which is distinguished as before stated from the eastern section, as a comparatively narrow strip, carrying hornblende and other ferro magnesium schists, with underlying basic and igneous rocks.

Surface occurrences noted are the Hillabee green schists, garnetiferous mica schists, and in the form of float, highly crystalline quartz, cyanite, and a small amount of cassiterite.

Characteristics of the pegmatite are parallelism with the average district rule as to N. E. to S. W. strike, and S. E. dip, and a distinct stratification in the enclosing rocks, which feature in large measure is shared by the quartz carried in the pegmatite itself; as also conformity by it with the enclosing foot and hanging walls, which are mica gneiss.

The mine has been opened up by means of an open entrycut, terminating in a slope driven down on the dip of the "vein" to water level, at which point work was abandoned for lack of pumping equipment. No timbering having been done, the heavy overhang, at the slope head in the cut, has recently fallen in since the property was first examined, blocking the mine. When examined before, prior to this caving in, mica crystals were observed on the slope, mainly next the hanging wall, and on both sides down to water level, where the grade and size of the crystals showed a marked improvement.

Small amounts of biotite mica have been occasionally found, and are observable in the quartz on the dump.

The pegmatite chute as far as developed is quite regular, having an average width of about 6 to 8 feet.

Practically all the work done here on the mine proper has been in hard rock, no kaolin in any amount being found, although elsewhere on the property in prospect pits at higher points kaolinization particularly under cultivated area of long standing is to a limited extent present.

On this western rim of the mica field, harder formations appear to be the rule with few exceptions, crustal movements are infrequent, and more regular stratification may be looked for with consequent benefits in the more marked absence of folding and of pressure cracks in the mica crystals.

In this deposit however, more than the usual amount of rule mica in large sizes appears to have been recovered, of very fine grade.

Actual mica mining has really never been done here, the operation having been abandoned for lack of experienced superintendence just at the point of definite recovery of the proper expectancy of the mine, viz: at and below water level.

No reliable total figures of mica recovery have been ascertainable, which solely consisted of the output realized in driving the entry cut and the short slope, approximately 100 feet in length.

Of the considerable mica stock recovered, the best and largest grades were sheeted and disposed of, and there remained in the bins of amber muscovite some 12 tons of run-of-mine scrap, apparently containing a considerable percentage of punch and circle, with some good sheet mica in medium sizes.

Exhibit sample, serial No. 125, is from this mine.

Hurst Mine.—The Hurst mine is located in the N. W. ¼ of the S. W. ¼ of Section 36, Township 19 S., Range 7 E., about 3½ miles N. W. of Ashland, the county seat.

Topographically, it is situated on a wide plateau broken by low hills, at an elevation of 1,200 feet above tide water.

It is the property of the Hurst estate.

The mica is mainly carried in a large bed of kaolin extending to a depth in excess of 80 feet, or to water level, which feature of the deposit has heretofore limited mica recoveries owing to the difficulty and dangerous character of the deposit without thorough timbering in the shaft and mine workings. Developments have in consequence been largely confined to open surface cuts.

In 1916, Mr. Joe R. Cook, of Birmingham, Ala., leased this mine and sunk an 83 foot shaft centrally of the old surface prospect pits, from which shaft, and in the short bottom entries, Mr. Cook recovered in all about 40 tons of mica.

Toward the foot of the shaft, and in the limited amount of stoping possible without much timbering, on the lowest level, very fine mica was taken out from the kaolin fully 25 per cent. of which was sheet mica running in sizes up to 6x8 inches.

As to grade the recovery was of flat sheet amber muscovite having in color a brownish caste in the thick sheet. Water coming in at 83 feet, requiring pumping and proper timbering, the operation was abandoned and no further mining has since been attempted.

Gibson Mica Mine.—The Gibson mica mine or prospect is located in the S. E. ¼ of the S. W. ¼ of Section 26, Township 19 S., Range 7 E., being about 2½ miles S. E. of Erin station on the A. B. & A. R. R.

It lies on the top (and midway of its S.E.-N.W. extension) of a ledge, forming the water shed between Mine creek and Buzzard creek (two branches of Talladega creek) at an elevation of 1,200 feet above sea level.

Some 20 years ago, a fine crystal of sheet mica of extremely large size, was found there almost on the surface outcrop, in a cultivated field, which find was the cause of the recent opening up of the pegmatite by Mr. D. F. Gibson, of Birmingham, Ala., who at that time purchased the property.

The work done by Mr. Gibson has been in the nature of prospecting, surface cuts having been made in and around the micaized quartz inclusions of a very coarse pegmatite outcrop, mainly in hard formations, sparingly kaolinized. No attempt was made to open up or to define the form and extent of the pegmatite body beyond the limits of such ordinary surface cuts, not exceeding in depth some 10 to 15 feet.

About 10 tons of mica was recovered in the course of sinking these test pits, practically all of which was still in the mica house when the last examination was made, none having been sold or disposed of to the trade. The run-of-mine examined, was necessardly hardly representative, and consisted mainly of small sizes, no more large mica having been found so near the surface.

In respect to grade, the recovered stock was largely flat sheet amber muscovite containing no spots or inclusions, but to some extent folded and surface cracked in the largest crystals, such imperfections becoming noticeably less at the depth reached.

Exhibit sample, serial No. 126 represents this run-of-mine stock.

Southern Mica Company.—Examination was made of four mica properties belonging to the Southern Mica Company of Birmingham, Ala., to which attention was called by Mr. Harry Watkins of that Company.

No actual mica mining so far as could be ascertained has ever been done on any of the properties, but all of them have been more or less prospected by the present owners. The four properties are known as the Dye, Smith, Hunter and Brown tracts.

W. D. Dye Property.—The W. D. Dye property is located in the S. ½ of the S. W. ¼ of Section 2, Township 19 S., Range 8 E.

Very little prospecting has been done as yet on an easily traceable micaized pegmatite dyke, clearly defined by outcrops along the south edge of and in part crossing, the bone of a narrow, sharply defined and high ridge, at an elevation of about 1,300 feet.

This pegmatite lead or dyke has a strike of N.30°E., dipping S. E. at the characteristically steep angle of this immediate section, approximately 80 degrees. The associated formations are all very similar to those observed at the M. & G. mica mine which is located 1½ miles to the S. E.

J. W. Smith Property. Location, the S. W. ¼ of the N. E. ¼ of Section 24, Township 18 S., Range 8 E.

On this lot a shaft has been sunk 27 feet in depth, which cuts across a pegmatite body carrying mica, 20 feet below the surface. As cut by the shaft, the micaized pegmatite is approximately 3 feet wide, and appears to carry mica of good quality bedded in kaolin. The dip of the "vein" (which is approximately 30 degrees S. E.)

brings it to the surface where it was first opened on the outcrop, some 40 or 40 feet N. W. of the shaft, in an open cut.

The shaft is located about 30 feet below the crest of the ridge. Following the outcrops of the pegmatite N. E., the deposit has a strike of N. 20 E. generally following but climbing the ridge to and over its crest.

The mica carried so far as developed, appeared to be altogether in the kaolin and of good quality, flat sheet amber muscovite, running to fair average sizes. Recovered amounts were not ascertainable. As the pegmatite lead could be opened at several other places where obviously mica bearing, the property can not be said to have been at all prospected or as yet proven as to the indicated values carried.

J. W. Hunter Property.—The J. W. Hunter property is located in the S. E. 1/4 of the N. E. 1/4 of Section 18, Township 18 S., Range 9 E.

Little or no prospecting of any value had been at the time of the examination done on this property, which could only be judged by the outcrops of two pegmatite leads crossing it, one and probably both of which are apparently mica bearing.

J. W. Brown Property.—The J. W. Brown property consists of the N. E. 1/4 of the N. W. 1/4 of Section 10, Township 19 S., Range 8 E.

A few small pits only had been opened up on this property, and some good mica taken out, but no competent prospecting done. It is located one mile N. W. of the M. & G., and 3/4 mile N. E. of the Eureka mica mines.

Weathers Old Mica Pit.—In the S. W. 1/4 of the S. E. 1/4 of Section 1., Township 20 S., Range 6 E., is located the "Old Mica Pit," as it is commonly called, on property belonging to the Weathers estate.

The history of this old mine can not be reliably ascertained; at what period it was originally opened, by whom, or for what initial purpose. Possibly it may have been one of the numerous cuts and shafts with which Georgia and Alabama were prospected soon after the Civil War, in a generally inexperienced and wild search for copper. The presence of the ferro magnesium formations, and of the

Hillabee green schists, may have been the determining cause on a copper basis for the extensive work first done here, which consisted of the removal of an elbow shaped surface cut some 150 to 200 ft. in length altogether, and nearly 20 feet deep. In the bottom of the cut are two shafts rumored to have been carried down to a considerable depth, but no accurate information is ascertainable about them, as they are full of water and choked with old timbers and debris. Later operations coming under the observation of old residents now living near by are stated to have been for mica.

Outcrops of mica occur in the sides and slopes of the old cut in many places, carried in soft kaolinized pegmatite. From long exposure, this mica had become rotten and soft, was of medium, running to extremely large sizes, and originally of good quality.

Examination of the old dumps taken from the body of the cut (and which from the size of the trees growing on them must have belonged to the original opening up of the mine) disclosed books of soft mica in considerable amount, of a copperish color resembling phlogopite, but an altered biotite.

To the west of the cut, on the Rader lot next adjoining it, this same peculiar class of altered biotite was found, embedded in the walls of a shaft about 15 feet deep, which had been recently sunk.

Exhibit samples, serial No. 127, is representative of this mica.

Haralson Mine.—A new mica prospect is just being opened up near Sardis Church, in Section 33, Township 19 S., Range 7 E., about 2½ miles S. of Erin station on the A. B. & A. R. R.

The deposit is being opened up by Miss Nellie Haralson of Talladega, Ala., and is developing some amber muscovite mica, in good flat crystals running in size to 3x4 inches.

Exhibit sample series No. 128 is from the mine.

COOSA COUNTY.

Coosa county lies almost altogether in the Piedmont plateau province.

Topographically, it is a very complex and irregular watershed of the various streams constituting a drainage area S. W. into the Coosa, and S. E. into the Tallapoosa rivers. In the western and north western portions, the country is rough and much broken up, ranging from hilly to mountainous, and reaching summit elevations of 1,000 feet above sea level. In the eastern and southeastern portions, the topography is much less abrupt, the hills and generally flat ridges seldom reaching an elevation above 300 to 500.

Mica occurrences have been noted at various points throughout the entire width from east to west of this county, to the east mainly undeveloped, most of the developed deposits being located in the western and northwestern portions, along the definite southwest extension into Coosa county of the mica belt as described through the counties of Clay, Randolph, and Cleburne, following their general and constant N.E.-S.W. strike.

The rocks of this section mainly consist as in Clay county of schists, gneisses, granites, diorites, phyllites, and slates, with occasional occurrences of shale and quartzite.

Mica occurrences in the county have received very little attention and no general study, recent interest and development having been altogether diverted to and centered upon the deposits of crystalline flake graphite which are extensive and valuable.

Ivey Mine.—The Ivey mica mine is located in the N. E. corner of the N. W. ¼ of the N. E. ¼ of Section 15, Township 22 N., Range 16 E.

It is situated about 1½ miles E. of Coosa river, at a point approximately midway between the present main power plant of the Alabama Power Company at Lock 12, and the projected new power plant to be constructed at Mitchell dam, six miles south of it, on Duncan's riffle, in Section 15, on which dam work is already well under way.

The mine was originally opened in 1889 by Dr. P. B. Ivey and G. W. McWade of Birmingham, Ala. Developments made by Ivey and McWade consisted of an open cut on the outcrop, and a shaft 25 feet deep subsequently lowered.

From a comparatively small open cut, and in the sinking of this shaft, there is said to have been taken out by these operators some 25 tons in all of mica, nearly twenty per cent of which is reported to have been run-of-mine sheet of various classes, subsequently worked up in the mica shop and sold.

Somewhere about 1912 to 1915 the mine is stated to have been leased to J. E. Burleson of North Carolina, the results, if any, of whose operation, were not ascertainable.

Subsequently, the mine remained inactive until 1920 when it was leased to the Coosa County Mica Company, during whose term of lease about 45 tons of mica in all was taken out, mainly won over a new slope, driven down 80 feet in the pegmatite from the entry point in the enlarged and deepened old cut marked "C" on the plan of the mine workings.

At this point, and in this operation, a large percentage of the mica recovered is said to have been of A-form. The slope having been back-filled could not be examined, and no samples were available representing the recovered stock taken out by the Coosa County Mica Company.

When visited in January of the present year 1921, development work had recently been in progress by the present owners of the mine, the Scott Investment Company of Montgomery, Alabama, but had just been discontinued owing to unfavorable weather and labor conditions.

A new slope was at that time being driven by the mine owners, located as shown at "A" on the plan, carried down on a 45° slope angle, which slope had been temporarily abandoned at water level, 40 feet down, for lack of adequate pumping facilities.

Little or no lagging was used or required in this slope except at the top, as it lies altogether in the hard and firm red mica schists which constitute both the foot and hanging walls enclosing the pegmatites.

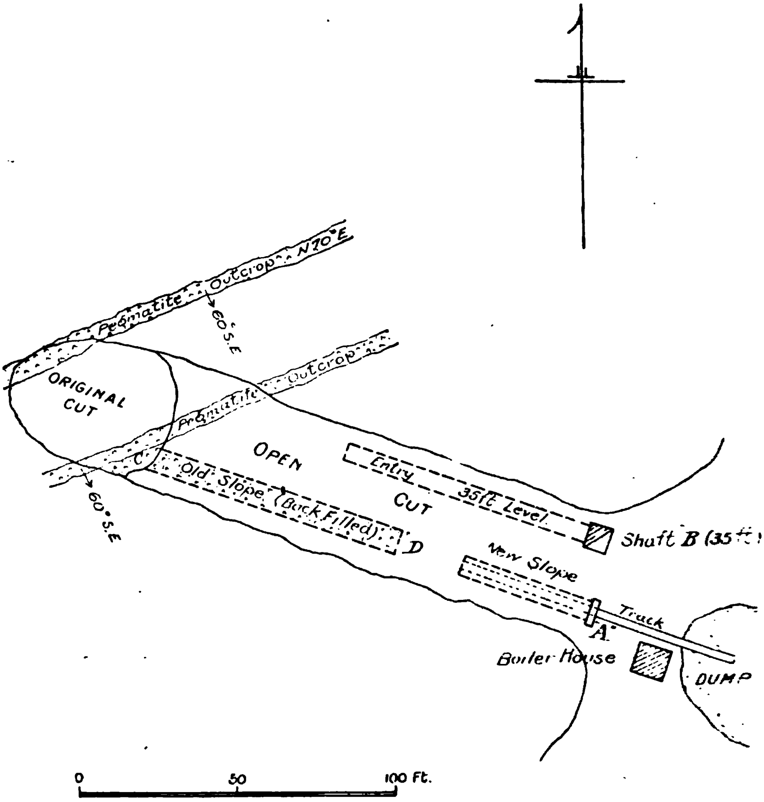

Figure 6.
PLAN of THE IVY MICA MINE
S15. T.22N. R16E.

The pegmatite body or bodies developed by this mine have the appearance of being either lenticular, the lenses overlapping, or are split (where cross cut by the old open workings), by an intrusive mass or horse of red mica schist.

The general strike of the "vein" is N.70°E., the dip being 60-65 degrees S. E. The various methods of entry adopted by the different operators have apparently had in mind only the simplest and most rapid recovery of mica with the least possible expenditure of time and capital, and have had no reference to permanent and most economic continuous mine operation.

From the fact that kaolin, some undecomposed feldspar, quartz, and mica show in the shaft all the way down from top to bottom for some 30 to 40 feet (the measures so cut, dipping as stated 60° S. E.) an overlying lenticular mass is here indicated separate and distinct from the underlying pegmatite chute, originally outcropping where it had a thickness of only 6 inches, widening to 2′6″ at the lowest point reached in stoping it down.

This overlying and larger pegmatite chute, which would appear to be by far the best expectancy of the mine, has thus far received no practical test, either as to its micaized condition in the direction of its strike, or to proper depth following the dip to lower levels.

The pegmatite has no unusual characteristics and lies in apparent conformity with the enclosing schists. A comparatively small amount of quartz of large size has been thus far found to be a component part, and as is generally the case, the best mica recovered has been found on and near such enclosures of larger quartz aggregates.

Also the best grade of mica recovered has been at the lower levels, where A-mica was of less frequent occurrence or altogether absent, and as stated, no test has yet been made of what should be the best expectancy of the mine, viz; below water level.

Other developments made by present mine owners, consisting of the deepening of the old Ivey shaft and the driving of a west horizontal entry some 80 ft. from the bottom of the shaft, were of small practical value or utility for obvious reasons, the entry not having reached the original or underlying ore body, and being largely placed in the intervening schists.

In the various and more recent operations of the present owners, approximately 2,000 lbs. of flat sheet mica are stated to have been recovered, ranging in size from 1½x2, to 4x6 inches. Occasional small amounts of biotite have been encountered in the mine.

One car load of scrap was recently taken out and sold, the run-of-mine sheet mica, being knife trimmed and roughly squared to stock sizes.

During the last period of continuous operation a daily average output of about 1,000 lbs. is stated to have been realized, with a working force of 7 men, by the simple use of pick and shovel, hand drilling, and primitive methods generally. Exhibit sample, serial No. 129 is from this mine.

Pond Mine.—The Pond mine is located about 2 miles due W. of Rockford (the county seat) in the N. W. ¼ of the S. E. ¼ of Section 15, Township 22 N., Range 18 E.

It is a recent development, having been opened in 1920 by the owner Mr. H. W. Pond of Rockford, the work being mainly done by and under the direction of Mr. W. F. Fletcher.

The property lies on the crest of a rolling and irregularly eroded ridge, at an approximate elevation of 700 feet, tidal datum.

Although only one of them has been as yet attempted to be prospected, some three or more parallel leads of pegmatite are by well defined and in places bold outcrops, indicated as crossing the property, having a strike of N.30°E., and dipping at a steep angle of some 60-70° S. E., the approximate width of the belt made up of the separate formations being 300 to 400 feet.

Mine development has been by means of two shafts, the main shaft, about 50 feet in depth, and the upper or westerly shaft, 10 ft. deep, connected by a stope on the slope angle of the pegmatite.

At the foot of the incline stope and bottom of the main shaft horizontal entries or rooms, running N. E. 10 feet and S. W. 30 feet constitute the working mine. From the entries and stopes about 12 tons of mica in all were stated to have been taken out and partially disposed of to the trade.

At the time of the examination, in March 1921, about 2 tons remained in the mica house of punch and scrap, with some 500 to 800 lbs. of run-of-mine sheet thumb trimmed.

Exhibit sample series No. 130 is from this remaining stock, and possibly not fairly representative.

Cowart Mines.—Three localities were examined belonging to Mr. J. C. Cowart of Rockford (resident on the property owned) and on which recent mica development work has been done by Mr. W. C. Fletcher. The localities developed all lie about one mile S. of the Pond mine, and about 2 miles S. W. of Rockford.

The S. E. ¼ of the N. E. ¼ of Section 21, Township 22 N., Range 18 E.

On this property a shaft had been sunk 30 ft. to water level, with a 10 foot entry in the pegmatite at its base. The pegmatite driven through is an aggregate made up of kaolin, quartz in considerable amount but of small size, in angular fragments, and mica; the mica being of small sizes, somewhat wavy, and having a slightly greenish caste.

About 400 lbs. in all had been recovered and was piled up on the ground. The deposit is called by Mr. Fletcher the "Hatchet Vein."

The N. E. ¼ of the N. W. ¼ of Section 22, Township 22 N., Range 18 E.

Developments here made by Mr. Fletcher were by a shaft 15 feet in depth, from the bottom of which a stope had been driven down following the dip of a pegmatite chute about 2 feet wide for a distance of 30 feet.

The mica found was altogether of A-form near the surface, improving at the lowest depth reached, where it occurred in connection with kaolin of fine quality.

About a ton of scrap mica was lying on the dump, mostly of A-form.

The S. W. ¼ of the N. W. ¼ of Section 22, Township 22 N., Range 18 E.

On this property a shaft had been sunk 35 feet deep from which a drift had been run out east 30 feet altogether in soft kaolin, no mica in any amount having been recovered.

E. E. Brown Property.—The S. W. ¼ of the S. W. ¼ of Section 11, Township 22 N., Range 18 E.

About 50 yards west of the Rockford Road, a shaft 35 feet in depth had been sunk by Mr. Fletcher in a soft white schist. A small deposit of mica had been cut into near the bottom of the shaft at water level containing only crystals of small size.

Mica outcrops of favorable character are of frequent occurrence in the cuts and along the main road leading from Rockford N. E. to Kellyton for a distance of eight or nine miles, but no developments have been made except in the vicinity of Crewsville, and on both sides of the crossing by this road of Jack's creek, in Sections 34 and 35, Township 23 N., Range 19 E., in which localities some mica mining has been done, not however in recent years.

There is a considerable area in that vicinity which from appearances is mica bearing, and might be well worthy of investigation.

Thomas Mica Properties.—Openings have been made and some mica mined on the properties of J. H. and E. B. Thomas located 4 miles east of Rockford near Hissop. From the developments made quite an extensive deposit of A-form and fish-bone mica is indicated, as also a fine flake mica in a decomposed schist, which may have utility by some method of concentration. The prevailing rocks are granite and gneiss. The location has been noted before in publications of the Ala. Geological Survey for the occurrence there of beryl crystals of yellowish green to aquamarine color in the quartz outcrops.

Exhibit samples, serial No. 131 are from this property.

CHILTON COUNTY.

The extreme south western end of the Alabama mica belt is comprised within that portion of eastern-central Chilton county, lying west and southwest of Coosa river, and east of the Louisville and Nashville Railroad.

Its general geologic conditions are precisely similar to those occurring in the adjoining section of S. W. Coosa county, east of Coosa river, of which area it is the S. W. extension.

Mica occurrences of indicated value have been noted and to some extent opened up in this section of the county, but systematic efforts at development have been prevented by litigation of long-standing in the courts, affecting the common ownership of the mineral interest in some 30,000 acres, inclusive of the mica bearing properties.

The close proximity of these deposits to present available hydro-electric power, should be a favorable factor in their development, if they prove to be extensive and valuable, as soon as the ownership questions now in litigation are definitely and finally settled or adjusted.

PART III.

KAOLIN.

AS BEFORE stated, the utilization of the kaolins, which are the almost universal accompaniment of the mica deposits of Alabama, should be, as a by-product, an important economic factor in assisting mica development.

No systematic study has as yet been given to these kaolins to determine their precise commercial value, both in the raw state, and properly prepared (by separating out the quartz and mica components) for use in porcelain making, and in the finer grades of pottery manufacture, for which purpose they have unquestionable adaptability.

Sufficient tests however have been from time to time made to show that the finer grades of pottery have been and can be made from these kaolins, and it remains to be clearly proven by reliably exhaustive and expert tests, that the amounts of such clays available at given points are sufficient to justify the necessary mining and flotation plant equipment.

As a result of careful study given to the mica-kaolins in the recent going over and examination of all or nearly all of the actual mica developments in the state which is just concluded, together with prior study and examinations covering a period, at intervals, for some twenty-five years given to the subject, it may be stated with all due conservatism, that in economically recoverable amounts these kaolin by-product accompaniments of mica are present in sufficient amounts and necessary concentration at a considerable number of localities.

In arriving at this estimate, attention has been centered upon the three essential factors, viz: the area indicated of the kaolin beds individually, the depth to which the spars have disintegrated, and the variable amounts and character of the over-burden carried.

The usual and competent boring tests made by clay experts, should when made bear out this statement, and prove these facts conclusively.

In every notable instance of important kaolin deposits, water supplies, amply sufficient for flotation, are present and closely adjacent.

Throughout the mica field, timber for mine, plant construction, and fuel purposes, is generally present in sufficient amount for a considerable period of operation, and as previously stated, hydro-electric power, either already on the transmission lines, or in the making is now and will be in larger amounts subsequently available as a permanent future basis of economic power for plant and mine operation, by reason of its frequent proximity, and the fair and favorable ruling rates for contract power service.

In view of these facts, such analyses and partial tests as have been at various times made, become of sufficient interest to be here stated as possibly justifying the complete, competent, experienced, and thorough study of Alabama mica-kaolins, which it is confidently hoped may soon be made.

Attention was first called to the value and possibilities of Alabama porcelain clays by Michael Tuomey, State geologist, in the second report made for the Alabama Geological survey in 1855.

Following the suggestions and opinions advanced by Tuomey, the Alabama Kaolin Company, later on in 1888, (acquiring large property holdings at and near Micaville, including the above sections) submitted proper samples of clay from that locality for testing to Mr. Henry Brunt, manager of the Chesapeake pottery, Baltimore, for practical pottery test.

Preliminary to these practical commercial tests the following analyses were made of the Micaville kaolin.

DEPARTMENT OF THE INTERIOR.
UNITED STATES GEOLOGICAL SURVEY.
DIVISION OF CHEMISTRY.

Report of analysis No. 943. Sample of Kaolin for analysis:

	%	
Water H_2O	18.50	5.02% at 120°C. 13.48 at red heat.
Silicia SiO_2	43.21	
Aluminum Oxide Al_2O_3	37.27	

Calcium Oxide CaO	**.11**
Magnesium Oxide MgO	**.10**
Potassium Oxide K_2O	**.28**
Sodium Oxide Na_2O	**.40**
Iron Oxide Fe_2O_3	**Trace**
	99.87

The feldspar is the normal potash feldspar containing a very small amount of iron, .25%.

Examined by Charles Catlett and reported July 26th, 1887.

(Signed) W. F. Hillebrand,
Acting Chief Chemist.

(Note)—Sample from Section 7, Township 18 S., Range 11 E., Randolph County, Ala.

In the letter of transmittal of the above analysis Mr. Hillebrand says:

"The supposed kaolin has been analyzed in full and found to possess practically the composition of a pure kaolin. Whether it is suitable for use in the manufacture of porcelain can only be determined by subjecting it to tests of a practical character which this laboratory cannot undertake to execute.

"This information can best be obtained by submitting samples to some manufacturer of pottery or porcelain.

"The feldspar would doubtless be suitable for the purpose of porcelain as it contains but a minute quantity of iron."

Samples of the quartz, feldspar, and kaolin, drawn from the same locality, and submitted for laboratory test in 1889 to the State chemist, N. T. Lupton, at Auburn, Ala., were analyzed and reported on as follows:

N. T. Lupton, State Chemist.
State Chemical Laboratory.
Auburn, Alabama.

March 4, 1889.

The specimens of Feldspar, Kaolin and Quartz from Mr. J. R. Abrams of Greenville, Ala., have been carefully analyzed with the following results:

	Feldspar	*Kaolin*	*Quartz*
Moisture	**0.20**	**6.45**	**— —**
Water of Combination	**0.80**	**13.25**	**0.20**
Silicia	**63.13**	**42.63**	**98.45**
Alumina	**21.18**	**37.26**	**0.87**
Iron		**----- -----**	**— —**
Lime	**Trace**	**.048**	**Trace**

Magnesia	1.08	Trace	——
Sodium	3.93	——	——
Potassium	9.38	——	——
	99.70	100.07	99.52

(Signed) N. T. Lupton,
State Chemist.

Out of the samples of Randolph county kaolin sent to Mr. Brunt for practical test, there was made up 6 ornamental and decorative pieces of transparent china, consisting of framed plaques, mirror frames, cups and saucers, and 10 pieces of opaque porcelain, consisting of plates, cups and saucers, flower vases, etc., which were entered in competition with other potteries at an exhibition held in Philadelphia in November 1889, and were there awarded medals and honorable mention in seven classes, taking, as stated by Mr. Brunt, "first prize in open competition with all American manufacturers."

Commenting on this exhibit, and its eminently successful results, Mr. Brunt says:

"The chemical composition of the clay is almost the same as that of the celebrated St. Stephens kaolin from Cornwall, England. I have not used any mineral stain, the material being entirely free from iron, and there being no foreign coloring matter to counteract. The clay has been burned in the biscuit kiln to about 3,000° F., and about 2,700° F. in the glass. Being entirely free from coloring matter, a little difference in temperature during burning does not alter its color. The leading idea throughout has been to produce an opaque porcelain body from American materials, as pretty and artistic as French china and as durable as English earthenware at a moderate expense—with a body and glaze obtained on different principles from those on which American porcelain of the present day is produced, recognizing the fact that the great fault with American earthenware heretofore has been its want of durability. The materials are from virgin mines in Alabama, and I have worked on the principle of using more to produce a body not so susceptible to variations of temperature."

The above practical test, and its judgment by the leading clay experts of this country, would seem to be con-

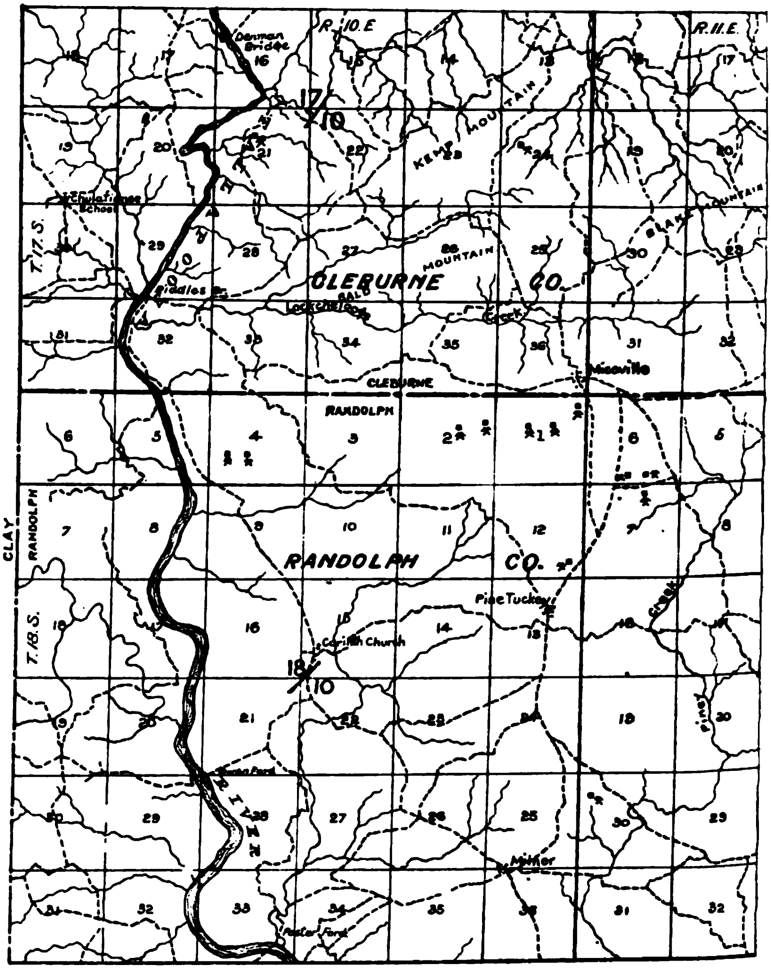

Figure 7.

MAP
SHOWING LOCATION OF
MICA MINES
In the vicinity of Micaville.

clusive evidence of the availability of Alabama kaolin for porcelain manufacture.

Subsequently, a tentative proposition was made by a leading pottery to erect a plant in this State, provided sufficient amounts of kaolin of the grade used in these tests could be convincingly shown by practical tests to be available.

The above detailed analyses and tests were as stated based upon the mica associated kaolins of the Micaville district, Randolph county.

Exhibit samples, series No. 132 represent this kaolin.

For possible utility in the manufacture of fire brick, the mica-kaolins have also been given some consideration.

At the time that samples of Micaville kaolin were submitted by the Alabama Kaolin Company to Mr. Henry Brunt for pottery test, mixed samples from the same locality, composed of quartz, feldspar, mica, and kaolin, were also submitted for refractories testing in the manufacture of fire brick.

The analysis of the samples submitted was as follows:

DEPARTMENT OF THE INTERIOR.
UNITED STATES GEOLOGICAL SURVEY.
DIVISION OF CHEMISTRY.

Report of Analysis No. 1148.
Labelled "Fire Clay."

Material received from J. R. Abrams, Greenville, Ala.

Material consists of fragments of quartz, feldspar and mica intermixed with about 40% of what is apparently Kaolin. Analysis made on material as sent in.

	Per Cent.
Water at 110°C., H_2O	.06
Water at red heat, H_2O	6.72
Silica, SiO_2	69.84
Alumina, Al_2O_3	19.91
Ferric Oxide, Fe_2O_3	.90
Manganese Oxide, MnO	Trace
Lime. CaS	.07
Magnesia, MgO	.28
Potash, K_2O	2.14
Soda, Na_2O	.21
	100.13

Examined by Thos. M. Chatard and reported Feb. 25th, 1890.
(Signed) F. W. CLARK,
Chief Chemist.

Out of 70 per cent. of the mixture above described, with an admixture of 30 per cent. of an ordinary plastic clay, Mr. Brunt prepared specimen bricks which stood the most rigid tests, having been finally subjected to a temperature of 5,000° F. for three weeks in a steel melting furnace without showing any sign of fusing.

The completion of the test as to the ultimate fire resistance of the brick in respect to time, was prevented by the fusing of the supporting and underlying brick in the bridge wall, there having been insufficient material furnished out of which to build the bridge wall entire.

During the year 1920, similar tests although not carried to the point of actual pottery manufacture, were made by the Coosa County Mining Company on the associated mica-kaolins from their Mica Hill mine near Dadeville, Tallapoosa county, representing an entirely different district, locality, and environment.

The physical characteristics however of the two clays were very similar, and their composition as shown by the following analysis differs very slightly.

THE BATTLE LABORATORY.

Montgomery, Alabama, Nov. 10, 1920.

No. 70994. Analysis of Sample Kaolin.

Received from the Coosa Co. Mica Co., Wetumpka, Ala.

	Per Cent.
Moisture	2.42
Silica	45.62
Oxide of Aluminum	38.26
Combined water	13.24
	99.64

Note.—A very pure Kaolin Clay.

(Signed) THE BATTLE LABORATORY.

In co-operation with the Alabama Geological Survey further tests of this clay were made by Dr. H. Ries of Ithaca, New York, at the instance of Dr. Eugene A. Smith, State geologist.

Quoting from Dr. Reis report to Dr. Smith he says:

"The clay sample submitted is evidently a white residual clay, in fact it is one of the whitest I have ever seen.

It contains but little coarse grit but seems to have quite a few small scales of white mica.

A sieve test shows that all of the clay except 9.7 per cent. passed through a 200 mesh sieve. It would however be desirable to wash the product, or put it through a process of air separation before shipping it to market.

"A sample of the clay was put through a series of physical tests, but previous to this it was washed through an 80 mesh sieve. The porting passing through was then allowed to settle and dried. This washed clay is very white, but its plasticity is not very high, in fact it is lean, and has a mealy feel. It would require to be mixed with a more plastic clay before it could be molded in pottery making.

"With this low plasticity there is also a rather low strength to the material in its air dried condition. This was determined from the modulus of rupture which was 40 lbs. per sq in.

"The linear shrinkage in air drying was 7 per cent. and is normal.

"The clay was fired at six different temperatures, and the shrinkage and absorption noted after each except the last. The results follow:

Temperature	*Fire Shrinkage*	*Absorption*
950°C.	0.0%	Too soft and porous.
1150°C.	4.0%	35.2%
1190°C.	5.0%	30.0%
1230°C.	6.0%	23.5%
1310°C.	6.0%	15.0%
1730°C.	Nearly fused.	

"These tests showed that the clay fires to a very porous body, characteristic of most true kaolins. It does not become steel hard until above 1190° C., and the color after firing is very white. Neither the linear air shrinkage nor the fire shrinkage are excessive.

"The clay appears to be an excellent one. Its white burning character together with its refractoriness should make it of value in the manufacture of porcelain, white earthenware, electrical insulators, or other wares in which this type of clay is required.

"I further believe in its washed condition it could be sold to paper, rubber or paint manufacturers, as these several industries consume a considerable quantity of white gritless clay."

In line with the results of the above tests made by Dr. Reis and his suggestions, samples of this clay were submitted to the Mercer Pottery Company of Trenton, New Jersey, and after testing resulted in an order for a sample carload, which was shipped to Trenton in April of the present year, the car-load being crude run-of-mine.

This large sample has since been worked up but the results have not yet been ascertained. Exhibit sample, series No. 133 was drawn from this car load shipped to Trenton, N. J., and represents the run-of-mine kaolin.

Preliminary flotation tests are now being made for the Coosa County Mica Company on the run-of-mine mica-kaolin from the Dadeville mine, to determine the best and most economic method for washing this clay, which will effect a clean preparation of kaolin, together with the complete separation of the small amount of finely divided quartz from the mica carried in the tails;; giving three clean products, the relative commercial values of which individually, so prepared, it is proposed to ascertain by submission of samples to the trade.

In a preliminary test just completed by the Simplex Ore Separating Process, using a four cell flotation machine with hydraulic agitation, a practically complete separation of the three products was experimentally effected without difficulty, the test being conducted under the supervision of Dr. D. C. Picard of the Picard Laboratories.

It is apparent from this test that the desired handling of this particular clay presents no difficulties other than those which are clearly understood and have been successfully solved by various methods.

The flow sheet of a satisfactory plant would be simple. and would probably be made up of some best adapted form of disintegrator, followed by four flotation cells (three rougher and one kaolin) the product to be handled over Wilfrey or Overstone tables, with final recovery of the washed kaolin in settling tanks.

Exhibit samples, serial No. 134, represent the flotation test above described, being drawn from the heads and tails during the experimental run.

In the index to the Mineral Resources of Alabama, issue of 1904, by the Alabama Geological Survey, additional analyses of the kaolins (which is the term uniformly used here to designate only the residual material from the decomposition of feldspars in the area of the crystalline or metamorphic rocks) are given and are quoted as further evidence of the comparative uniformity and favorable character of these mica-kaolins in other localities of the mica belt, for porcelain making.

†*Composition of Kaolins.*

Locality	Silica	Alumina	Ferric Oxide	Lime	Magnesia	Alkalies	Ignition	Total
1. Washed Kaolin, 1½ Mi. N. E. of Milner, Randolph County	47.75	38.00	.20	*	*	*	14.85	100.80
2. Washed Kaolin, 1½ Miles S. E. of Micaville, Cleburne Co.	45.20	38.00	*	.22	*	*	15.90	99.32
3. Kaolin, J. B. Ross, Miller Place, Micaville Cleburne Co.	46.88	39.97	.08	.30	*	.64	13.87	101.74
4. Kaolin from S½ S. S. 28, Tp. 18, R11E. Senator McIndoe, Randolph County	42.41	38.33	....	....	.70	....	17.42	....

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*Trace.

†Mineral Resources of Alabama 1904 Ala. Geological Survey.

3627 051

POCKET CONTAINS
1 ITEM(S)

3 2044 102 943 842